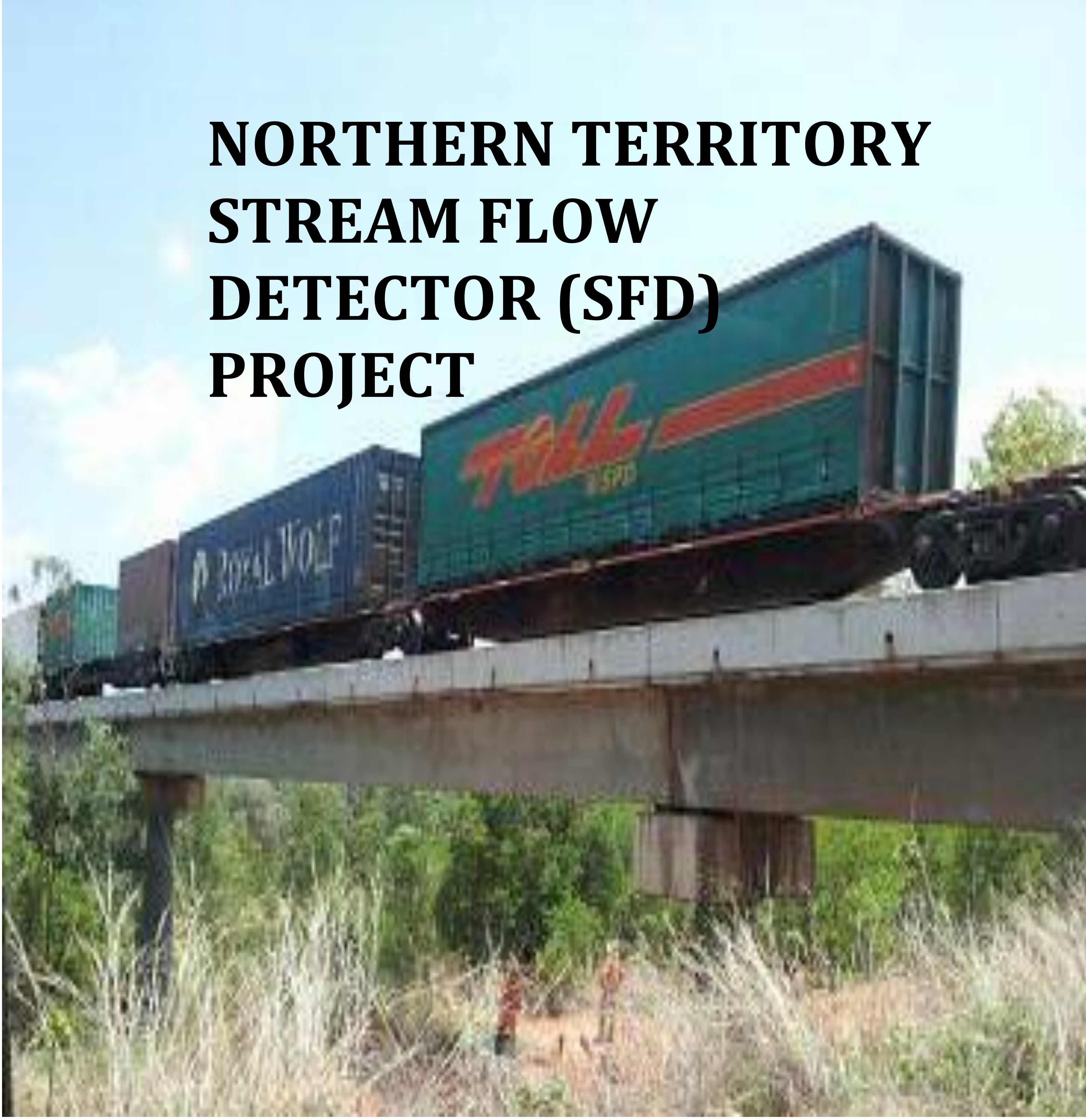
NORTHERN TERRITORY STREAM FLOW DETECTOR (SFD) PROJECT



Engineering Internship Report

4/13/2013
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MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

ODG HADEN
INTEGRATED ENGINEERING

1 Executive Summary

Derailment caused by flooding has been an issue in the Northern Territory. Stream flow detectors (SFDs) and the associated equipment are designed, supplied, installed and commissioned across six river locations in order to reduce the risk of derailment for trains owned and operated by Genesee & Wyoming Australia (GWA). This document details the full life cycle of the Northern Territory Stream Flow Detector Project (SFD). This project is essentially a warning system that provides alarm to train control as well as an indication to the train drivers when the river reaches a certain level.

This report describes the process of the engineering design for each major component within the system and identifies the main factors that had a large influence in the design of the project. This included the clients' requirements, poor access to sites and availability of the equipment. For example, these factors particularly had a large influence in the design of the solar panel masts; the difficulty was caused by the clients' requirement for the solar panels to be raised off the ground floor. The heavy weight of solar panels and poor site access required a unique solar panel mast design. The engineering design section also details the location case (LOC) design, power calculations, indicator mast design, Miri telemetry radio design, SEAR II design and the electrical connections design.

Subsequently, this report further describes the process of the procurement and fabrication. More distinctly, the focuses on the methods of obtaining and fabricating materials that hold short lead times and the processes that are implemented to ensure Australian standards are met. This includes using the correct wire sizes for the application, as well as the correct colours and fittings, etc. Fabrication was performed by certified rail electricians.

The report also describes the Construction and Installation stage which details in the development of site preparation to meet the clients' requirements. This phase was also performed by a construction team specific to the rail. Outcomes of construction and installation achieved site locations that are complete to test. However, a few minor installation issues are identified in this report; this includes the positioning of the LOC's and indicators.

The Testing & Commissioning section details the procedures that are necessary to provide verification that the SFD system is working correctly. Results from Testing & Commissioning show that the Earth resistance values do not meet the clients' requirements of 5 ohms due to sandy site locations. However, all sites were verified as fully functional and operational. Most importantly, all sites were commissioned and approved by the client.

A discussion of maintenance and upgrades is also provided. An evaluation of the SFD project life cycle identifies that the project is proven to be reliable, maintainable and fully operational. Overall, this document displays the development and successful completion of the project.

2 Disclaimer

The work discussed in this entire document is the work of the author unless otherwise referenced.

I declare the following to be my own work, unless otherwise referenced, as defined by Murdoch University's policy on plagiarism.

X

Charlotte Moss
Student

3 Acknowledgements

Firstly, I would like to thank O'Donnell Griffin Haden who not only gave me the opportunity to complete my Internship but have supported me through the entire course, particularly, Adrian Gould, Mick Simm, Wayne Lansdown, Alistair Ballie, Ben Millman, Edin Huremovic, Angelo Ciavarella and John Ma. This experience has allowed me to understand the transition from University to the Engineering workplace and has been the most rewarding learning experience of my life.

Appreciation goes to my supervisors, Project Manager Asa Brown, Technical Manager John Cole and my Academic Supervisors, Sujeewa Hettiwatte and Martina Calais for their support and guidance.

I would like to thank Murdoch University staff members Associate Professor Graeme Cole, Dr. Gareth Lee and Dr. Gregory Crebbin who have taught me for most of my time at University. They have provided me with the skills and knowledge that I need to become a good Engineer.

Appreciation also goes to my fellow students who have been a part of my development at Murdoch University and have provided me with the encouragement and assistance throughout my degree.

I would also like to thank my family for their support throughout my Internship.

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5 Tables and Figures

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6 Purpose

The purpose of this report is to demonstrate the process and outcomes of the Engineering Internship that took place at O'Donnell Griffin Haden from 15th August 2012 to 28th February 2013. The Internship is intended to demonstrate the students overall competency within their ultimate year of the Engineering degree by judging their performance when positioned in an engineering workplace. This document will deliver in detail the students involvement with Northern Territory Stream Flow Detector (SFD) Project.

6.1 Aims

The main aims that the student shall achieve from the Internship are:

- Experience from tendering to commissioning
- Delivering a quality product within a specific time frame
- Engineering practice

6.2 Persons Involved

The main persons involved in the Internship are:

- The Student, Charlotte Moss
- The nominated ODG Haden Supervisor(s): Adrian Gould, John Cole and Asa Brown
- The nominated academic supervisor, Sujeewa Hettiwatte

6.3 Implementation

The Engineering Internship was implemented by:

- Actively working at ODG Haden a minimum of three days a week
- Scheduled meetings with supervisors
- A Project Plan, submitted 4 weeks from the commencement of the Internship
- A Progress Report, submitted 16 weeks from the commencement of the Internship

6.4 Definitions and Abbreviations

6.4.1 Definitions

Table 1: Definitions

Terminology	Definition
Approver	A competent person nominated by O'Donnell Griffin Haden with the responsibility and authority to approve designs
Aspect	What the signal Displays (red, yellow, green)
Checker	A competent person experienced to a sufficient level in the design and documentation of Rail to undertake the checking role in a thorough and complete manner
Client	GWA Pty Ltd
Contractor	O'Donnell Griffin Haden
Designer	A competent person experienced in the design and documentation of railway systems
Hazard	Anything with the potential to cause harm to a person, equipment or the environment
Indications	What the aspect means (its definition)
Lugs	Compression-style crimp
Procedure	Specified way to carry out and activity or process
Process	Set of interrelated or interacting activities which transforms inputs to outputs
Safe Working	The system of safely organising train movements on a railway network
Validate	A series of checks to determine whether the system is working as per the design

6.4.2 Abbreviations

Table 2: Abbreviations

Abbreviation	Meaning
AS	Australian Standards
ATCS	Advanced Train Control System
BSOC	Battery state of charge
BTS	Battery Temperature Sensor
CAD	Computer Aided Design
DBS	Design Briefing Sheet
FAT	Factory Acceptance Test
FMG	Fortescue Metals Group Ltd
GSM	Global System for Mobile
GWA	Genesee & Wyoming Australia Pty Ltd
HSE	Health, Safety & Environment
IOMP	Iron Ore Major Projects
JHA	Job Hazard Analysis
LOC	Location case
LUI	Local User Interface
LX	Level crossing
MDR	Manufacturers Data Report
MPPT	Maximum Power Point Tracking
NT	Northern Territory
OC	Open Circuit
PET	Primary Earth Terminal
PPE	Personal Protective Equipment
RF	Radio Frequency
RSSI	Received Signal Strength Indication
Rx	Receive Value
SAT	Site Acceptance Test
SC	Short Circuit
SEAR II	Safetran event analyser recorder II
Seq	Sequence

SFD	Stream Flow Detector
SIM card	Subscriber Identity Module card
SMS	Short Message Service
SOW	Scope of Works
TC	Train Control
TCA	Transient Clamp Arrestor
TCS	Train Control System
Tx	Transmitter
UHF	Ultra High Frequency
WA	Western Australia

7 ODG Haden

O'Donnell Griffin Haden is a leading establishment in the design and construction of integrated rail signalling, power and communications systems. The integration of the rail scheme facilitate the full life cycle of rail system solutions (Company Overview n.d.)

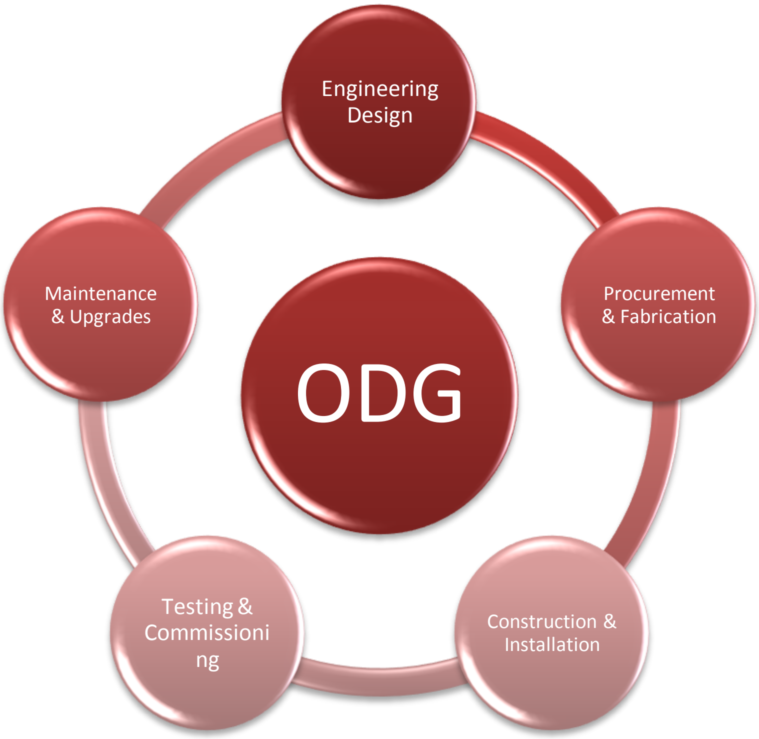


Figure 1: Process of the Integrated Rail Systems

Engineering Design is the initial evaluation of the clients' requirements. This is where any technical issues are answered and an engineering solution and direction for the project are decided.

Procurement and Fabrication are the implementation processes of the engineering design. These will determine lead times for equipment and ensure that the designs comply with the clients manufacturing standards.

Construction and Installation organises the site for the fabricated equipment and builds structures in accordance with the client's requirements.

Testing & Commissioning is the final evaluation of the clients' requirements. This part of the process allows adjustments and is essential for the preparation previous to handover.

Maintenance and Upgrades, ODG is capable of upgrading any project and provide a period of fault free maintenance when requested by the client.

8 Northern Territory Stream Flow Detector Project

8.1 Project Objectives

In order to reduce the risk of derailments, Stream Flow Detectors (SFD's) and the associated equipment shall be installed and commissioned at the specified sites.

The scope of work involves the minimum requirements to carry out the design, supply, install and commission the SFD's and ensure 10 days of backup power supply at each site. The Contractor shall provide a fully functional solution that is standardized, well documented and entirely operational. Works include design, supply, construction and commissioning at the following sites:

- Elizabeth River
- Adelaide River
- Cullen River
- Fergusson River/ Backup Creek
- Edith River
- Katherine River

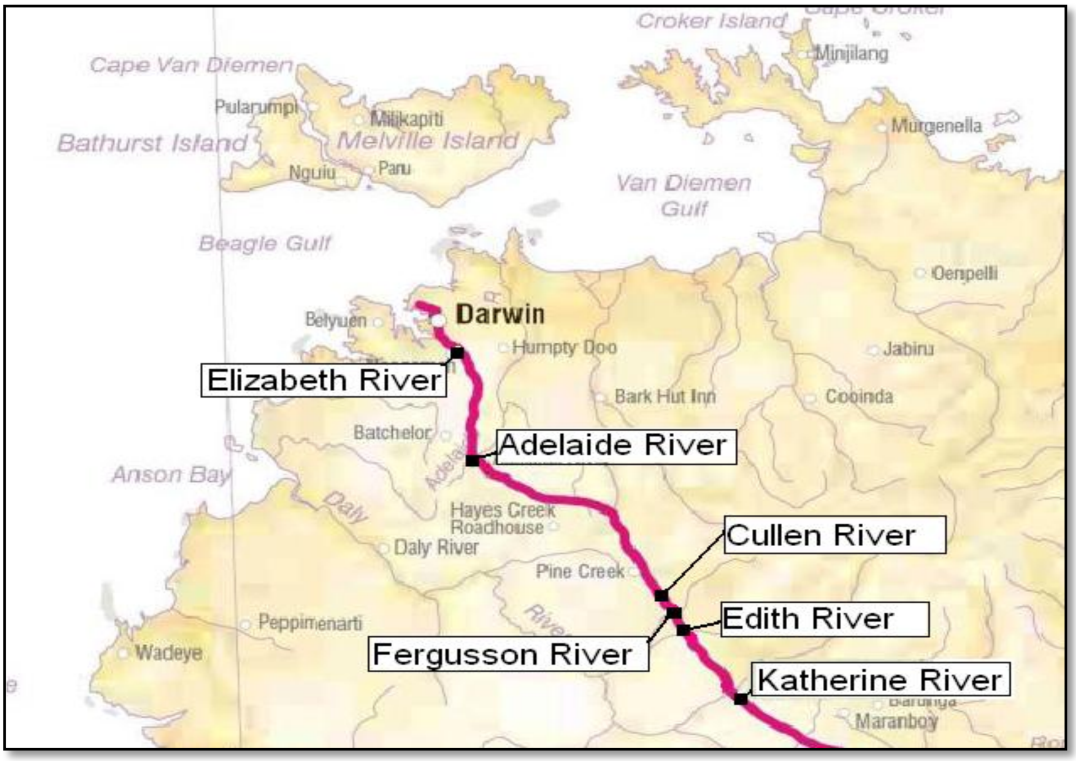


Figure 2 : GWA Track Line

8.1.1 Technical Highlights

To accomplish the typical layout for the standalone installations includes the following works:

1. Provide new or modify asset protection and associated equipment to monitor and provide alarms back to train control (TC) for SFD.
2. Provide new or modify existing radio communication network to establish the communication between TC System and wayside locations.
3. Provide new or upgrade existing solar arrays and battery capacity to increase the power supply for modified signal and asset protection locations.

8.1.2 Student Participation

Throughout the course of the project, the student assumed the role of Project Engineer and was to participate in:

- Establishing the scope of works (SOW)
- Establishing, confirming and allocating the design requirements derived from client, contract and stakeholder specifications
- Providing technical support to the Project Manager
- Purchasing
- Customer liaison
- Coordinating, assisting and managing technical activities through the lifecycle of the project

8.1.3 Site Specifics

Elizabeth River SFD Site and Edith River SFD Site are interfaced with level crossings. A level crossing is the intersection between a railway line and a road, it requires extra equipment, and therefore, they do not follow the standalone system. This report will only discuss the design, supply, installation and commissioning of the standalone systems.

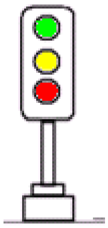
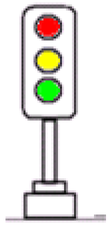
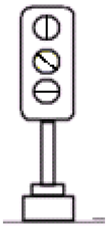
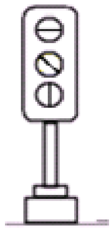
8.2 Background Information

8.2.1 Railway Signals

Although there is no universal layout of the railway signals, the only set rule is that the red aspect is to be positioned at direct eye level. In some circumstances, it may be at the top, as it is with a road traffic signal. Typically, the red aspect will be positioned at the bottom of the signal (see Table 3) as that position will be most in line with the drivers' eyes. In countries affected by snowy conditions, this arrangement allows the red aspect to be free from the build-up of snow caused by the hood of the lower aspect.

Also, the green aspect can be observed at further distance when it is positioned at the top. Therefore, the train driver can maintain high speed and thus, sustain production.

Table 3: Railway Signals

Railway Signals	Traffic Lights
	
Schematic	
	

8.2.2 Genesee & Wyoming Australia (GWA)

Figure 3 : GWA Rail (Image taken on 18/12/2012)

Genesee & Wyoming Australia Pty Ltd (GWA) offer nationwide transport of bulk cargo that consists of grain, steel, gypsum and minerals in addition to terminal operations. Also, GWA provide contracting services including “locomotives, wagons and crews, for freight forwarding on the interstate rail network” (Operations n.d.).

8.2.3 GWA Derailment

A train controlled by GWA derailed on 27th December 2011 at Edith River Rail Bridge in the Northern Territory. Although the train driver was uninjured, the co-driver suffered back injuries and substantial damage was impacted on the mixed freight train and the track itself.

The derailment was caused by “the wash-away of the south-eastern embankment, associated sub-grade and ballast on the approach side of the Edith River rail bridge. The magnitude of the wash- away meant that the track could not support the weight of the train, initiating the derailment.” The flooding occurred from the stormy conditions caused by Cyclone Grant. (Probe into why derailed NT was dispatched 2012)

The effects of the derailment not only include the damage to the mixed freight on the train but also environmental effects. The derailment resulted in “spilling up to 1200 tonnes of toxic copper concentrate into the Edith River” (Probe into why derailed NT was dispatched 2012) as two of the thirty three wagons contained copper concentrate. “NT Environment Department chief executive Jim Grant said copper concentrate ‘is recognized as an environmental hazard and is a threat to aquatic life, but that although it contains arsenic and silica it is not rated as highly toxic’.” (Samuel 2012)

“ As a result of the derailment at Edith River Rail Bridge, on 27 December 2011, GWA has undertaken a range of actions to enhance its policies, procedures and employee training with respect to managing the risks associated with server weather events. GWA will also enhance its systems for alerting staff to severe weather events, including flood risks." (Derailment of freight train 7AD1 at Edith River near Katherine 2012). Figures 4,5,6,7 and 8 show the impact of the GWA derailment.

Figure 4 NT Derailment 1 (Image supplied by Project Manager 2012)

Figure 5 NT Derailment 2 (Image supplied by Project Manager 2012)

Figure 6 NT Derailment 3 (Image supplied by Project Manager 2012)

Figure 7 NT Derailment 4 (Image supplied by Project Manager 2012)

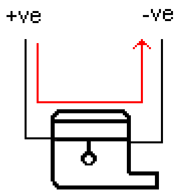
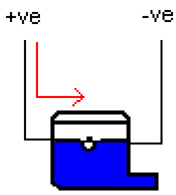
Figure 8 NT Derailment 5 (Image supplied by Project Manager 2012)

8.2.4 SFD

A stream flow detector is an essential component of the flood warning system. It initiates an alarm to inform train drivers that the track ahead may be obstructed by a flooded river.

For this particular project, the SFD is designed with a float switch located inside the tank. When the water level reaches the float switch, the circuit becomes de-energised and an alarm is set to display a yellow aspect on the indicators. This will notify the train driver to reduce speed. Its advantage is that it is a failsafe design because it requires the contact to break when the water reaches the float switch as shown in Table 4.

Table 4 : SFD Operation

SFD Operation		
SFD ON		The float switch is down, the circuit is energised
SFD OFF		The float switch is up, the circuit is de-energised

ODG Haden use this simple SFD design because of the following factors:

- GWA Requirements
- Reliability
- Availability
- Time constraints
- Cost

The design of an SFD may be simple but it is a crucial safety feature within railway systems.

Mechanically, the SFD is designed with an extra wall to allow the water to fill up smoothly and prevent the float switch from oscillation caused by the water.

It should be noted that the SFD used in this project does not measure the flow of water but rather detects a certain level of water in the river. There are many other types of stream flow detectors in the industry that measure flow rate and offer other functionalities for specific applications.

8.2.5 Previous SFD usage

The same type of SFD has been utilised in previous projects within ODG. Fortescue Metals Group Ltd (FMG) includes two SFDs at different heights; it uses logic to determine the corresponding aspect. The logic for this operation is shown in Table 5.

Table 5: Logic operation

Row	SFD 1	SFD2	Resulting Aspect
1	1	1	Green
2	0	1	Yellow
3	0	0	Red
4	1	0	Yellow

Row 1 exhibits both SFDs are on, in which, proving that the track is clear and resulting in a green aspect.

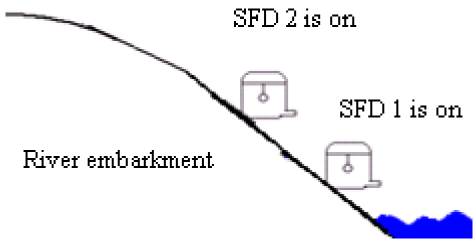
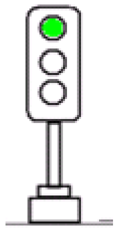
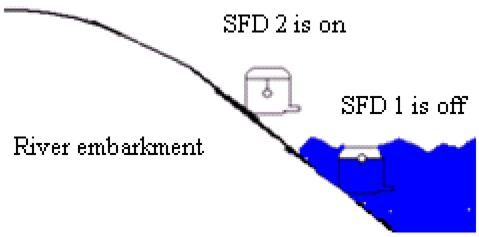
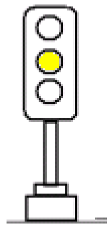
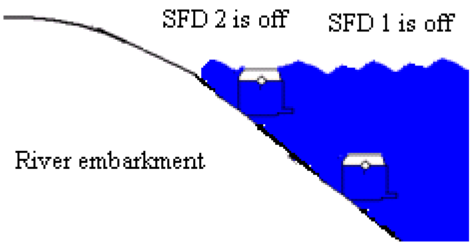
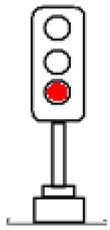
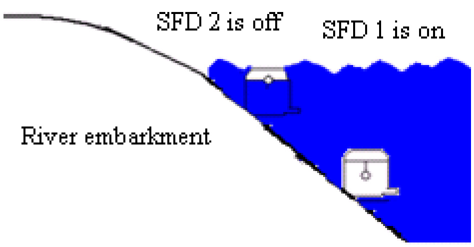
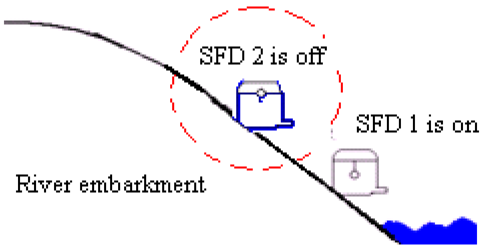
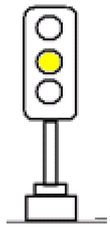
Row 2 shows that the SFD 1 is off and SFD 2 is on, resulting in a yellow aspect.The yellow aspect informs the driver to reduce speed usually to about 40km/hr.

Row 3 displays both SFDs are off, proving that the track may not be clear and resulting in a red aspect which informs the train driver to stop. A warning aspect is required when a red aspect is involved as the train driver needs sufficient warning time to stop the train in a safely manner. However, due to GWA‘s requirements and time constraints, the design for SFD NT Project is less complex and does not incorporate a red aspect.

Row 4 shows a situation where SFD 2 is off and SFD 1 is on this could be a result of two possible failures; either the SFD 1 has failed to de-energise whilst the river is high or SFD 2 has failed to energise whilst the river level is low. It will ultimately result with a team of rail technicians to evaluate the fault.

A visual interpretation of this logic is demonstrated in Table 6.

Table 6: FMG SFD Logic

Row	Operation	Aspect
1		
2		
3		
4	 Or 	

9 Engineering Design

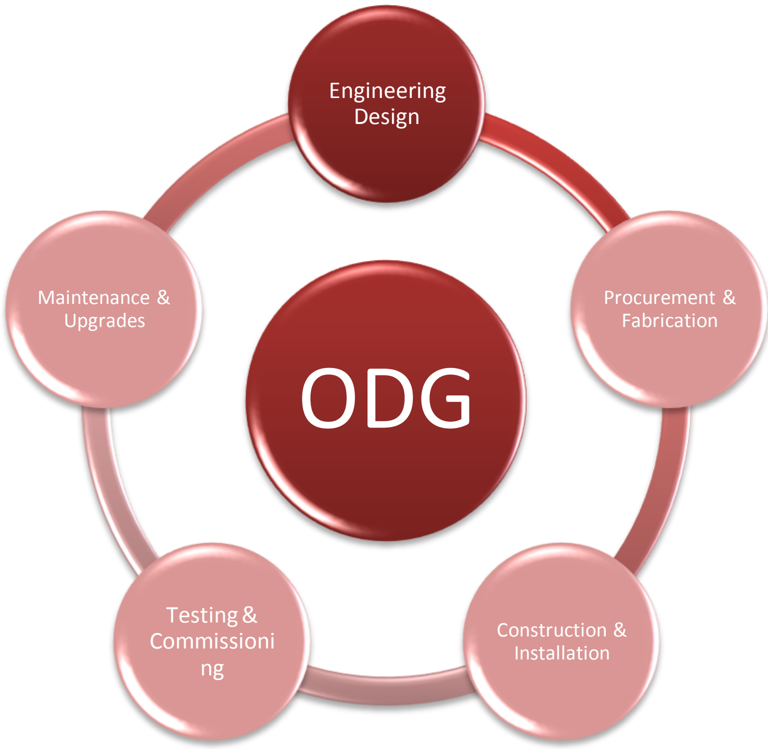


Figure 9: Engineering Design

Engineering Design is the initial evaluation of the clients' requirements. This is where any technical issues are answered and an engineering solution and direction for the project are decided. The following factors influenced the design:

1. **Client Requirements.** Most importantly, designs are created to meet the clients' requirements in the most safe and effective manner.
2. **Availability**. A time constraint can limit the supply of some materials; therefore the availability and lead times of materials have affected the outcome of the design.
3. **Robustness.** The designs are to be reliable and accurate.
4. **Installation**. Access to the sites is very difficult; the designs take into account the physical properties of the equipment as manual lifting may be required.
5. **Cost**. Cost is always considered in a project, in regards to this project the main objective is to stay within the budget.

9.1 Overall Concept

Each river location will have an SFD site and two Indicator sites. The concept for the SFDs standalone system is displayed in Figures 10 & 11 .The following occurs when the river is low:

- The SFD is ON
- The bi-directional radio transmits a one (1)
- Green aspect indicates the route is clear

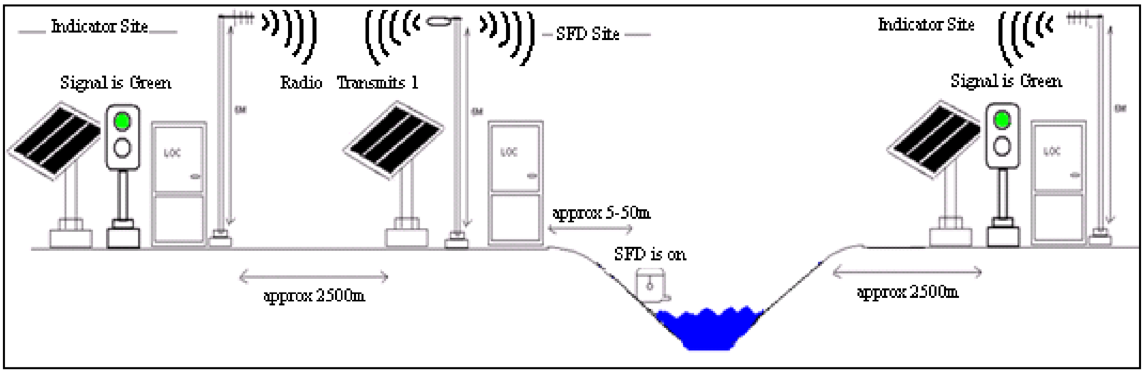


Figure 10 Standalone System - River low

When the river is high:

- The SFD breaks the circuit
- The radio transmits a zero (0)
- Yellow aspect indicates to the train driver to reduce speed
- Global system for mobile (GSM) modem sends a high alarm to TC

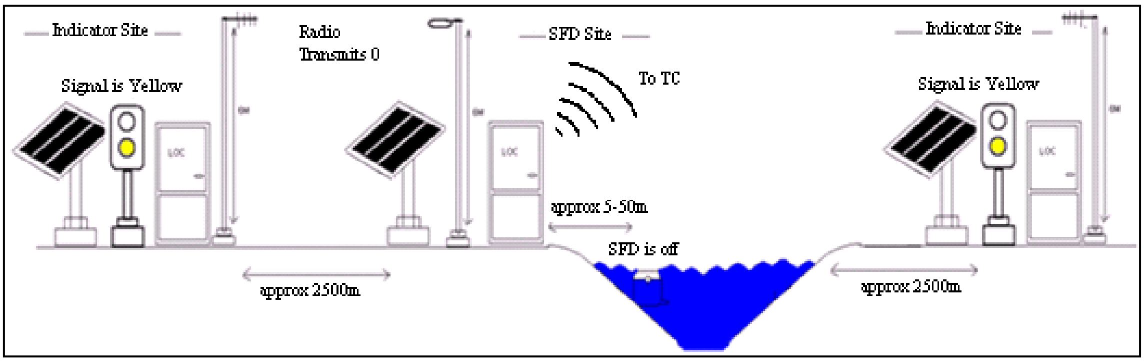


Figure 11 Standalone System River High

GWA has a clear train speed of 115km/hr, while a caution speed is reduced to approximately 40km/hr. The indicators are to be permanently illuminated. If a blackout was to occur, a blackout is treated as restrictive and the train is required to stop as soon as possible.

9.1.1 Positioning of the SFD

GWA states that the SFD is to be located between 5-50 metres from the track. Figure 12 shows that locating the SFD at 50m will provide a longer warning time, however, the greater distance from the track results with a larger possibility that a warning indication may be issued when the track is clear. This arrangement results with a less accurate alarm system. To improve the accuracy of the flood warning, locating the SFD 5m from the track will make certain that warnings are issued at critical situations however, the warning time decreases.

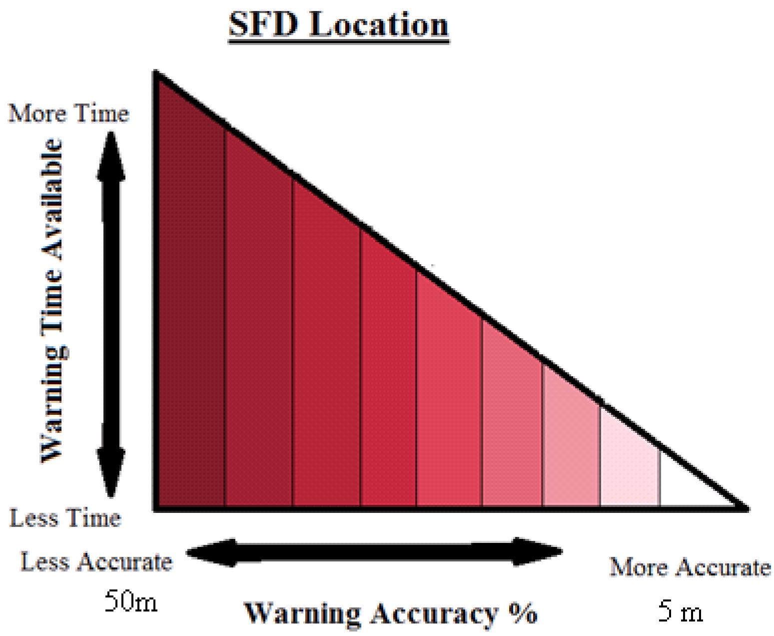


Figure 12 Chart of SFD Positioning

It is beneficial to locate the SFDs in place where it is able to accurately detect the track is flooded. The actual locations of the SFDs are determined on site between the Client Representative and the Construction Manager. The positioning of the SFDs incorporates factors such as:

- Historical data
- Accessibility
- Safety

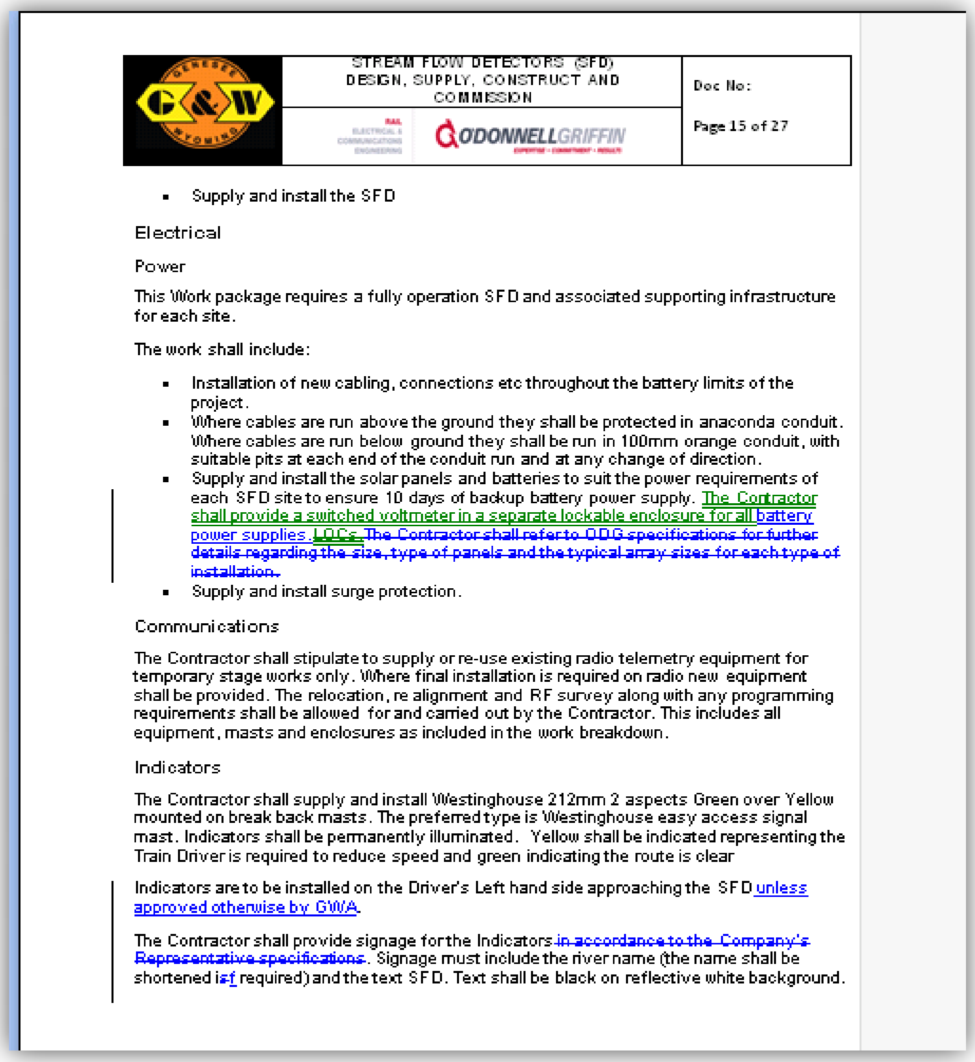
For example, at Fergusson River, the SFD is located at Backup Creek because when Fergusson River floods the water flows around the track to Backup Creek.

9.2 Scope of Works (SOW)

A Scope of works (SOW) is required to detail the requirements, procedures and guidelines that need to be carried out to meet the client's requirements.

9.2.1 Procedure

All information on the project needs to be examined to enable a full understanding and to create an accurate SOW. A draft is to be sent to the associated managers including the client to review, then instructed updates are made. An example of the Clients review is displayed in Figure 13.



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- Supply and install the SFD

Electrical

Power

This Work package requires a fully operation SFD and associated supporting infrastructure for each site.

The work shall include:

- Installation of new cabling, connections etc throughout the battery limits of the project.
- Where cables are run above the ground they shall be protected in anaconda conduit. Where cables are run below ground they shall be run in 100mm orange conduit, with suitable pits at each end of the conduit run and at any change of direction.
- Supply and install the solar panels and batteries to suit the power requirements of each SFD site to ensure 10 days of backup battery power supply. The Contractor shall provide a switched voltmeter in a separate lockable enclosure for all battery power supplies. ~~LOCs. The Contractor shall refer to ODG specifications for further details regarding the size, type of panels and the typical array sizes for each type of installation.~~
- Supply and install surge protection.

Communications

The Contractor shall stipulate to supply or re-use existing radio telemetry equipment for temporary stage works only. Where final installation is required on radio new equipment shall be provided. The relocation, re alignment and RF survey along with any programming requirements shall be allowed for and carried out by the Contractor. This includes all equipment, masts and enclosures as included in the work breakdown.

Indicators

The Contractor shall supply and install Westinghouse 212mm 2 aspects Green over Yellow mounted on break back masts. The preferred type is Westinghouse easy access signal mast. Indicators shall be permanently illuminated. Yellow shall be indicated representing the Train Driver is required to reduce speed and green indicating the route is clear

Indicators are to be installed on the Driver's Left hand side approaching the SFD unless approved otherwise by GWA.

The Contractor shall provide signage for the Indicators ~~in accordance to the Company's Representative specifications~~. Signage must include the river name (the name shall be shortened i~~s~~f required) and the text SFD. Text shall be black on reflective white background.

Figure 13 : Scope of Works

This task allows an opportunity to apply constructive feedback and redraft until a final version is completed and approved by all parties. The approved SOW is located in the Appendix F.

9.3 Power Calculations

9.3.1 Client‘s Requirements

Supply and install the solar panels and batteries to suit the power requirements of each SFD site to ensure 10 days of backup battery power supply.

9.3.2 Overview

The power calculations determine the amount of batteries and solar panels that are needed to maintain the power demands of each site and ensure that it meets the client’s requirements.

There are four SFD sites and twelve indicator sites that require power calculations and are all classed as standalone systems. The Power Calculations Report consist of an excel spread sheet, NSol graphs and the appropriate data sheets.

9.3.3 Power Calculation Spreadsheet

Table 7 identifies the assumptions that are made.

Table 7: Power Calculations Assumptions

O'DONNELL GRIFFIN RAIL	08-05-09 Power Calculation Sheet
ASSUMPTIONS	
1) Yellow LED assumed to be on at all times (worst case)	
2) 10% extra capacity is added to the daily load to allow for future expansion.	(modify if required)
3) The effective charging load is the load seen by the solar panels. This means taking the efficiency of the battery charging process into account. A figure of 85% is assumed. (MPPT Regulator efficiency is more than 90%)	
4) The daily power required from the solar panels is the minimum amount of charge that must be provided per day. Calculated as:	
Minimum Daily Charge = Array-Load Ratio x [(Daily Load + 10%) / Charging Efficiency]	(modify if required)
The mimimum amount of charge required by the solar panels needs to supply daily load including 10% allowance and recharges the battery to its full recovery from full discharge.	
5) The value entered here should be the minimum warranted power of the solar panel. Note: This is not always equal to the nominal power.	
6) Suntech 195W Solar Panels are warranted to produce 80% of the Minimum Warranted Power for 25 years.	
7) Maximum regulator current is based on maximum possible output from all of the 24V solar panels. This calculation assumes that all the solar panels are connected in series and a Xantrex XW-MPPT60-150 regulator is used to charge the 12V batteries.	(modify if required)
8) Modem is assumed to be in Active mode for a maximum of 2 hrs/day and in dormant mode for 22 hrs/day.	
9) Location Case Light is assumed to be used very rarely. 124 minutes (approx. 2 hours) per week is assumed.	

These calculations were based on the ODG Power Calculation spread sheet. (Millmen, Power Calculation, 2012). The Time on per day is the maximum amount of hours per day that the component will be on. The load values are found by observing the associated data sheets. The equations are located in Appendix E.

Table 8 is an example of the load calculation for Adelaide River SFD site.

Table 8: Power Calculations Loads

O'DONNELL GRIFFIN RAIL — **08-05-09 Power Calculation Sheet**

LOAD FROM CONTROL DEVICES

Field Equipment	Load Current (A)	Working Voltage	Qty	Total Current Required from Source(A)	Affected by Train?	Time Per Day (hrs)	Load Per Day (Ah)
2 Aspect LED SFD Indicators - Style L (Assumption 1)	0.650	12	0	0.00	N	24.00	0.00
SFD	0.12	12	1	0.12	N	24.00	2.88
LX Control Equipment	**Load Current (A)**	**Working Voltage**	**Qty**	**Total Current Required from Source(A)**	**Affected by Train?**	**Time Per Day (hrs)**	**Load Per Day (Ah)**
SEAR II	1.2	12	1	1.20	N	24.00	28.80
Total GCP Control Load				**1.20**			
Relays	**Load Current (A)**	**Working Voltage**	**Qty**	**Total Current Required from Source(A)**	**Affected by Train?**	**Time Per Day (hrs)**	**Load Per Day (Ah)**
Finder 40.52	0.054	12	1	0.05	N	24.00	1.30
Non vital Relays (OMRON LY4N)	0.12	12	2	0.24	N	24.00	5.76
Total Relay Load				**0.29**			
Power Equipment	**Load Current (A)**	**Working Voltage**	**Qty**	**Total Current Required from Source(A)**	**Affected by Train?**	**Time Per Day (hrs)**	**Load Per Day (Ah)**
Xantrex Solar Charge Controller (XW-MPPT60-150)	0.208	12	1	0.21	N	24.00	5.00
12-12V/3A DC-DC Converter (Mascot 8862)	0.04	12	1	0.04	N	24.00	0.96
Remote Monitoring Equipment	**Load Current (A)**	**Working Voltage**	**Qty**	**Total Current Required from Source(A)**	**Affected by Train?**	**Time Per Day (hrs)**	**Load Per Day (Ah)**
Miri AD2006 with On-board Radio	0.397	12	1	0.40	N	24.00	9.52
Total Remote Monitoring Equipment Load - 24V				**0.40**			
Communications Equipment	**Load Current (A)**	**Working Voltage**	**Qty**	**Total Current Required from Source(A)**	**Affected by Train?**	**Time Per Day (hrs)**	**Load Per Day (Ah)**
Maxom Modem (MM-6280IND) (TX) (See Assumption 8)	0.4875	12	0	0.00	N	2.00	0.00
Maxom Modem (MM-6280IND) (RX/Idle) (See Assumption 8)	0.0075	12	0	0.00	N	22.00	0.00
Maxom Intelimax Modem (MA-2015) - Active (See Assumption 8)	0.15	12	1	0.15	N	2.00	0.30
Maxom Intelimax Modem (MA-2015) - Dormant (See Assumption 8)	0.05	12	1	0.05	N	22.00	1.10
Total Communicaion Equipment Load - 12V				**0.20**			
Miscellaneous Equipment	**Load Current (A)**	**Working Voltage**	**Qty**	**Total Current Required from Source(A)**	**Affected by Train?**	**Time Per Day (hrs)**	**Load Per Day (Ah)**
Location Case Light (12V 13W Fluoro, (See Assumption 9)	1.1	12	0	0.00	N	0.10	0.00
Total Control Load Per Day (Ah)						**55.62**	
(See Assumption 2) Daily Load +10% (Ah)						**61.18**	
Estimated Load for 10 Days (Ah)						**611.82**	

The spread sheet is a useful way to evaluate the components in the design. Notice how each component has a working voltage of 12V.

Also, 10% is added for future expansion, this value is multiplied by ten to calculate the GWA requirement of a minimum of 10 days backup capacity at each site.

The equations that are used in the Table 9 are located in Appendix E. The Power Calculations use a Solar Array consisting of SunTech 195 Watt panels, Sonnenschein Batteries consisting of two by six volt 330AH cells and Xantrex XW-MPPT60-150 solar controller.

Table 9 Power Calculations for Solar Array

O'DONNELL GRIFFIN RAIL	08-05-09 Power Calculation Sheet	
POWER CALCULATION FOR SOLAR SUPPLY		
Battery Capacity Required	**611.82**	Ah
Battery Capacity with 80% Depth of discharge	**764.78**	Ah
Capacity of a Single Battery	330	Ah
Number of Banks Required	**3**	
Actual Battery Bank Capacity	**990.00**	Ah
Total days backup	10	day(s)
Total days to full recovery from 80% discharge	10	day(s)
Array-Load Ratio	**2.00**	
Charging Efficiency **(See Assumption 3)**	*85%*	
Minimum hours of full sunlight on a cloud-free day	5	hrs
Daily Load +10%	61.18	Ah
Minimum Charge Required Per Day **(See Assumption 4)**	143.96	Ah/Day
Backup Battery Voltage (this should correspond to the setting on the charger)	12	V
Solar Panel Minimum Warranted Power **(See Assumption 5)**	195	W
Solar Panel Warranted Power Percentage **(See Assumption 6)**	*80%*	
Solar Panel Warranted Power Output	156	W
Number of Solar Panels Required	**3**	
Maximum Possible Current Output (Short Circuit Current) for one Solar Panel at 24V	5.69	A
Maximum possible current output (Short Circuit Current) for one Solar Panel at 12V output end of Solar regulator **(See Assumption 7)**	11.38	
Maximum Possible Current from whole Solar Array at 12V output end of Solar Regulator **(See Assumption 7)**	34.14	A
Number of Chargers Required (Maximum charging current for a XW-MPPT60-150 solar regulator is 60A)	**1**	

The value for the minimum hours of sunlight was specified by the client. Table 9 identifies that the minimum array-to-load ration is 2. The array to load ratio is essentially the proportionality between the power being provided by the solar panels and batteries against the power being used within the system. (see Appendix E for the equations). Table 9 also identifies 3 solar panels are required as well as 3 battery banks.

9.3.4 NSol Software

NSol v4.4 is a sizing program that is designed for engineers to efficiently and accurately evaluate a diverse range of alternatives for a precise system. It is used as a verification source to confirm the calculated power requirements of each site.

The program's accuracy is supported by its database that contains information such as location details including: weather patterns for the exact co-ordinates, estimation of hours of sunlight hours throughout the year, as well as the angle of the sun throughout the year and the effect of heat on the solar panels. Figure 14 displays the setup of the system.

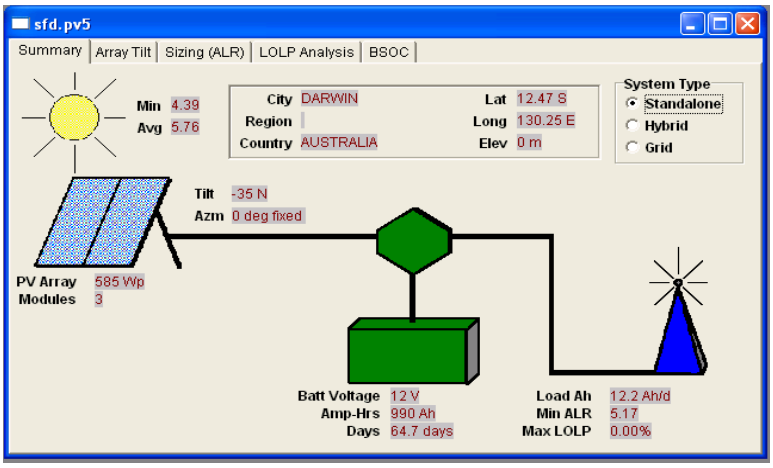


Figure 14: NSol

The values calculated in the spread sheet are entered into the NSol program. The Nsol software provides two useful graphs:

1. **BSOC** – The BSOC (Battery State of Charge) displays a monthly battery analysis over the course of a year. It is required because it "gives the user an indication of how much longer a battery will continue to perform before it needs recharging". (State of Charge (SOC) Determination 2005). For an acceptable result, the average battery state of charge should be between 95-100%.
2. **System performance analysis** –provides a breakdown of the system, the graph displays the monthly array-load ratio against the full system load to guarantee

that the system will meet the power demands. In order for a good system performance, the array-to-load ratio needs to be above the full load

Management instructed that the Nsol calculations are to use a standard -30 degree tilt for the solar panels. However, this value is later discussed in Section 9.3.7.

9.3.5 Standalone SFD Site Results

For the 12V system, Table 8 identifies the following:

1. It shows that the total load per day for the SFD standalone sites is 55.62 Ah.
2. The total load with 10% extra and meeting GWAs requirement results in a 611.82 Ah load for 10 days.

Table 9 shows that the SFD Sites require three battery banks and three solar panels in order to meet the client's requirements.

The system performance analysis in Figure 15 proves to meet the requirements. The reason for the increase in array-to-load ration over April to June is because it incorporates the weather pattern in its calculations. There are more direct sunlight hours over the dry season (April to November see Appendix A), hence, better output.

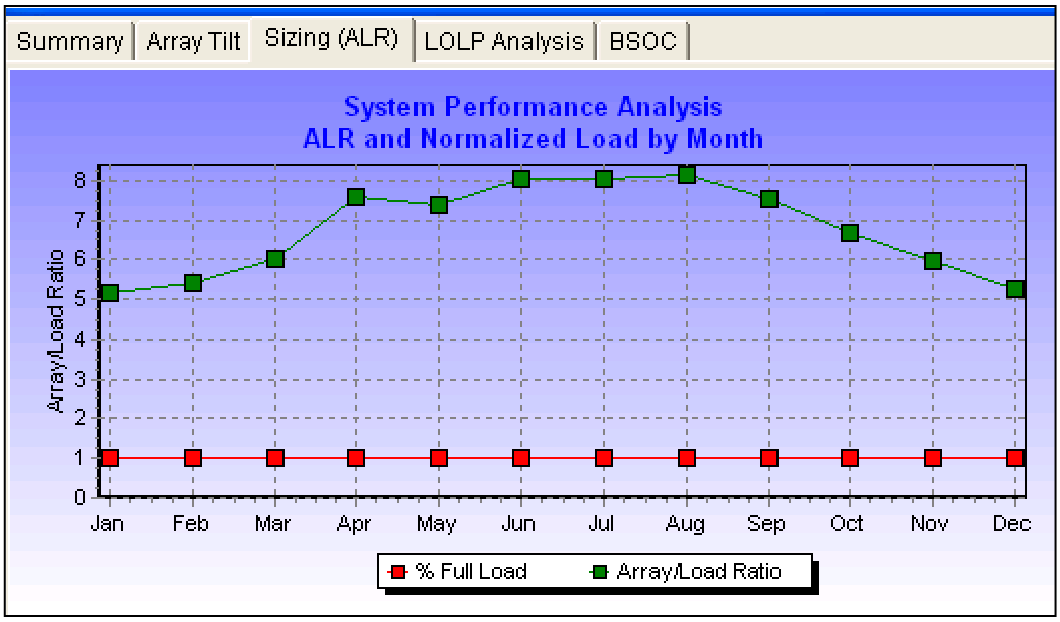


Figure 15: System Performance Analysis

It should also be noted that the array-to-load ration is 5 and above. This difference is a result of greater accuracy in the NSol software. Table 9 provided a minimum array-to-load ratio of 2 which effectively still meets the criteria because it is greater than the full load percentage displayed in Figure 15.

Figure 16 provides a month by month analysis of the anticipated battery state of charge (BSOC) for the SFD site. The reason for the decrease of approximately 1.5% over June and July is because the Nsol calculations include factors that affect the efficiency of the solar panels. The suns angle of incidence changes throughout the year and becomes lower during the dry season (April – November) which will affect the input power to the system during this time.

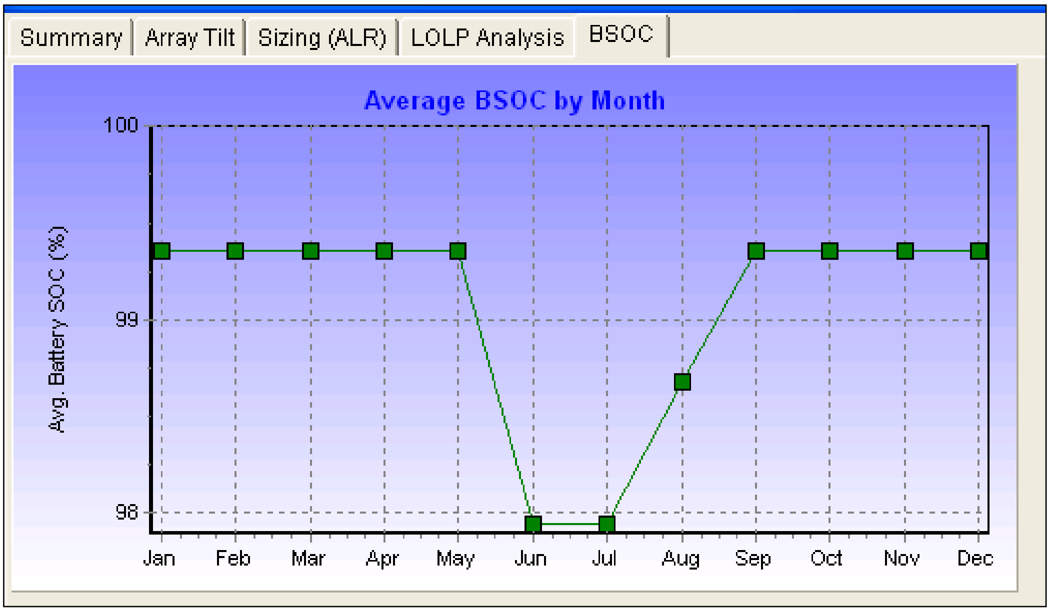


Figure 16: Average BSOC

Solar panels also become less efficient when they heat up (Solar Facts and Advice 2013), hence, June and July being the months with the most direct sunlight they become inefficient but the graph still provides evidence that the BSOC is acceptable for the system.

Figure 15 and Figure 16 agree with the results calculated in the Table 9, consequently, all standalone SFD Sites will use a Solar Array consisting of 3 SunTech 195 Watt panels. It will also use Sonnenschein Batteries consisting of 3 Strings of 2 by 6 volt 330AH cells. The solar controller is a Xantrex XW-MPPT60-150.

9.3.6 Stand Alone Indicator Site Results

The indicator sites require less equipment because of its different functionality from the SFD site. Table 10 identifies that the estimated load for 10 days including the 10% extra for future expansion is 408.98 Ah. This value is much less than the load for ten days at the SFD Site (611.82 Ah). With such a reasonable difference in load, it can be assumed that fewer batteries and solar panels will be required for the standalone Indicator Site.

Table 10: Power Calculations Indicator Load

O'DONNELL GRIFFIN RAIL — 08-05-09 Power Calculation Sheet

LOAD FROM CONTROL DEVICES

Field Equipment	Load Current (A)	Working Voltage	Qty	Total Current Required from Source(A)	Affected by Train?	Time Per Day (hrs)	Load Per Day (Ah)
2 Aspect LED SFD Indicators - Style L (Assumption 1)	0.650	12	1	0.65	N	24.00	15.60
Relays	**Load Current (A)**	**Working Voltage**	**Qty**	**Total Current Required from Source(A)**	**Affected by Train?**	**Time Per Day (hrs)**	**Load Per Day (Ah)**
Finder 40.52	0.054	12	1	0.05	N	24.00	1.30
Non vital Relays (OMRON LY4N)	0.12	12	2	0.24	N	24.00	5.76
Total Relay Load				**0.29**			
Power Equipment	**Load Current (A)**	**Working Voltage**	**Qty**	**Total Current Required from Source(A)**	**Affected by Train?**	**Time Per Day (hrs)**	**Load Per Day (Ah)**
Xantrex Solar Charge Controller (XW-MPPT60-150)	0.208	12	1	0.21	N	24.00	5.00
Remote Monitoring Equipment	**Load Current (A)**	**Working Voltage**	**Qty**	**Total Current Required from Source(A)**	**Affected by Train?**	**Time Per Day (hrs)**	**Load Per Day (Ah)**
Miri AD2006 with On-board Radio	0.397	12	1	0.40	N	24.00	9.52
Total Remote Monitoring Equipment Load - 24V				**0.40**			
						Total Control Load Per Day (Ah)	**37.18**
						(See Assumption 2) Daily Load +10% (Ah)	**40.90**
						Estimated Load for 10 Days (Ah)	**408.98**

As expected, Table 11 shows that Indicator Site only requires two banks and two solar panels as previously mentioned.

Table 11: Power Calculations Indicator Site

O'DONNELL GRIFFIN RAIL	08-05-09 Power Calculation Sheet	
POWER CALCULATION FOR SOLAR SUPPLY		
Battery Capacity Required	**408.98**	Ah
Battery Capacity with 80% Depth of discharge	**511.23**	Ah
Capacity of a Single Battery	330	Ah
Number of Banks Required	**2**	
Actual Battery Bank Capacity	**660.00**	Ah
Total days backup	10	day(s)
Total days to full recovery from 80% discharge	10	day(s)
Array-Load Ratio	**2.00**	
Charging Efficiency **(See Assumption 3)**	*85%*	
Minimum hours of full sunlight on a cloud-free day	5	hrs
Daily Load +10%	40.90	Ah
Minimum Charge Required Per Day **(See Assumption 4)**	96.23	Ah/Day
Backup Battery Voltage (this should correspond to the setting on the charger)	12	V
Solar Panel Minimum Warranted Power **(See Assumption 5)**	195	W
Solar Panel Warranted Power Percentage **(See Assumption 6)**	*80%*	
Solar Panel Warranted Power Output	156	W
Number of Solar Panels Required	**2**	
Maximum Possible Current Output (Short Circuit Current) for one Solar Panel at 24V	5.69	A
Maximum possible current output (Short Circuit Current) for one Solar Panel at 12V output end of Solar regulator**(See Assumption 7)**	11.38	
Maximum Possible Current from whole Solar Array at 12V output end of Solar Regulator **(See Assumption 7)**	22.76	A
Number of Chargers Required (Maximum charging current for a XW-MPPT60-150 solar regulator is 60A)	**1**	

Figure 17 identifies that the array to load ratio is substantially above the full load line and provides further evidence that two solar panels will supply enough power to the system.

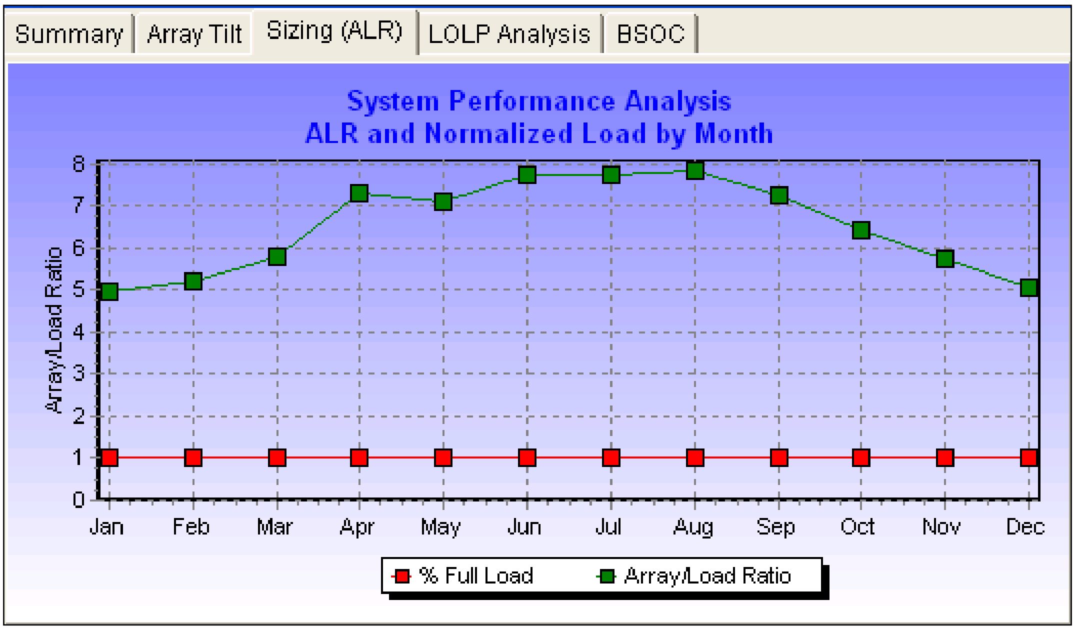


Figure 17: System Performance Analysis for Indicator Site

As stated earlier the drop in Figure 18 is a result from the weather patterns and the change in the suns angle throughout the year but the battery state of charge meets above 95%.

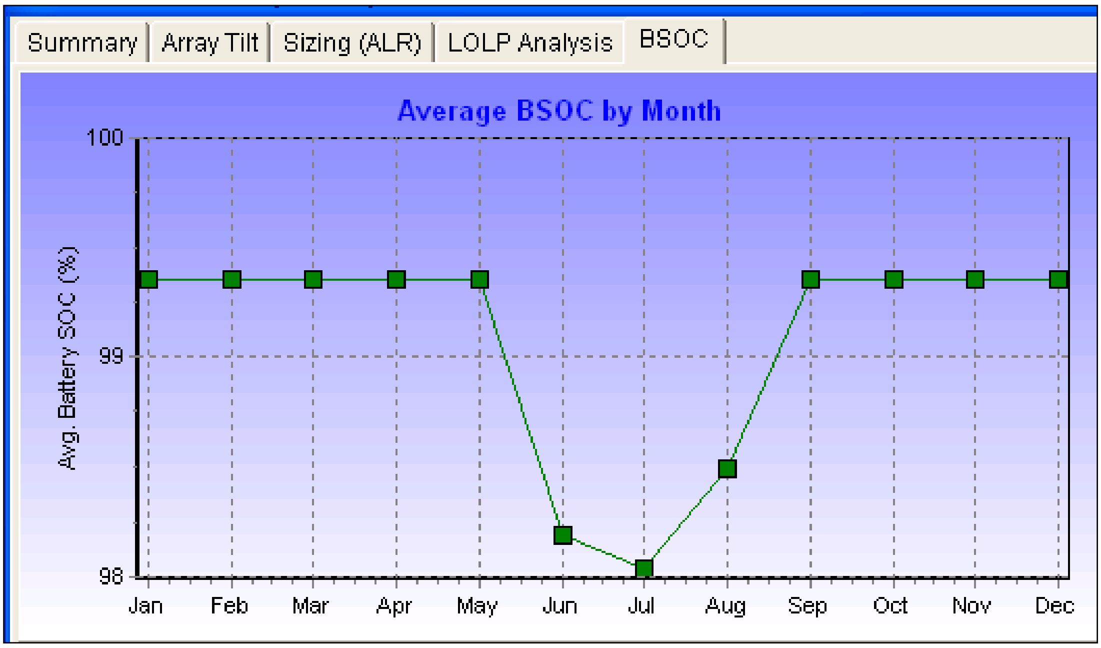


Figure 18: Average BSOC for Indicator Site

Although only two solar panels were required, management agreed that three solar panels will be installed at all Indicator sites. The Figure 19 & Figure 20 displays the system performance analysis and BSOC for three solar panels per site.

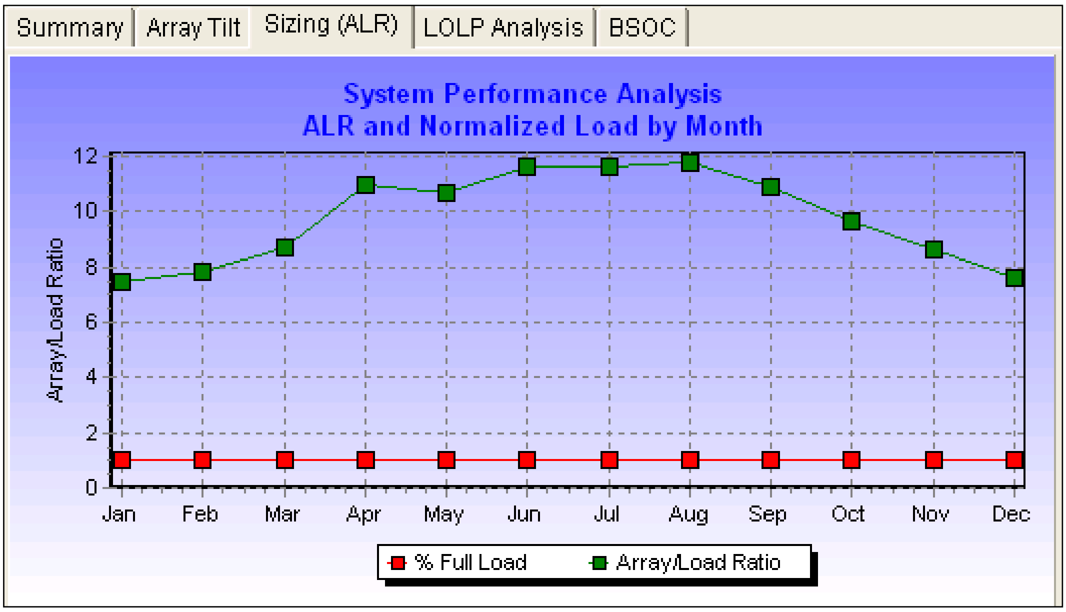


Figure 19 : System Performance Analysis Improved

The extra solar panel supplies extra power to the system and decreases the number of days from full recovery. Hence, the system performance analysis shows a rise in the array to load ratio against the full load.

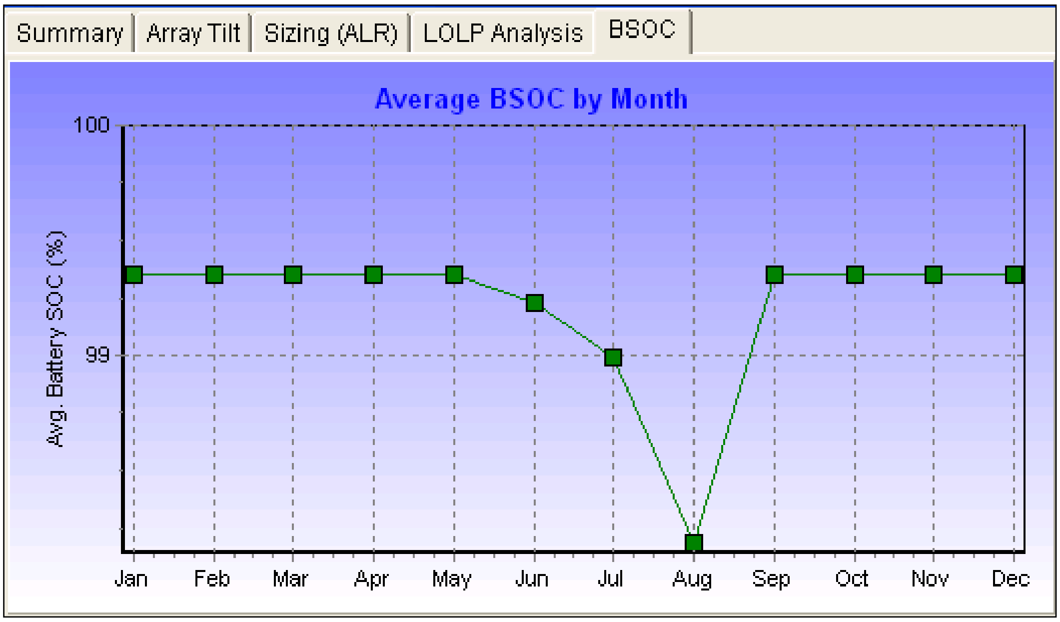


Figure 20: Average BSOC Improved

As expected, the BSOC graph (Figure 20) proves to be more effective when there are three solar panels.

Consequently, all stands alone Indicator Sites will use a Solar Array consisting of 3 SunTech 195 Watt panels. It will also use Sonnenschein Batteries consisting of 2 Strings of 2 by 6 volt 330AH cells.

9.3.7 Recommendations

To save on expenses, the use of two solar panels can be implemented at all indicator sites as the results show that two solar panels provide enough power to meet the clients requirements of 10 days backup capacity. The total cost of solar panels would decrease by one third.

Also to improve the battery state of charge, the tilt angle of the array can be altered to suit the site accordingly. 30 degrees was instructed because that is the angle used for the projects located in Port Hedland which consequently has a different angle of elevation from the sun than in Darwin.

For example, the average angle of elevation of the sun between the hours of 08:00 – 17:00 in Darwin is 72.5 degrees (Darwin, Australia - Sun path Diagram 2013). The power input is at its maximum when the surface of the solar panels and the sunlight are perpendicular to one another. The most effective angle for the solar panel is determined by:

$$90^\circ - 72.5^\circ = 17.5^\circ$$

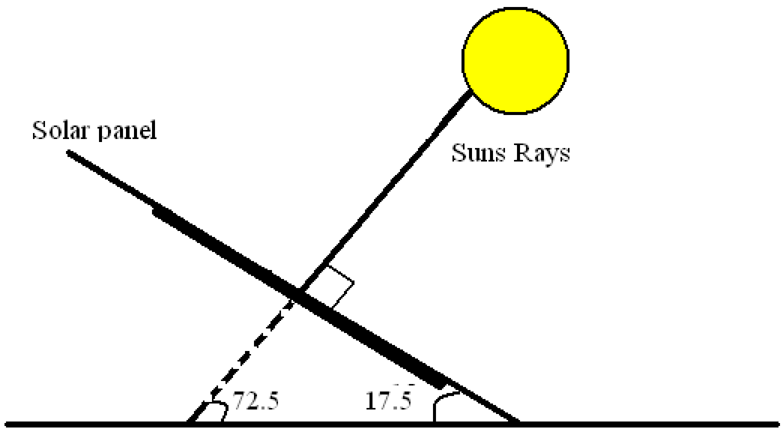


Figure 21: Suns angle of Incidence

The calculation identifies that 17.5 degrees is the average tilt angle to be used, it will accommodate for the change in the suns elevation throughout the day.

The angle of the solar arrays has a great effect on the solar radiation absorbed by the panel. For a fixed solar array angle, "the maximum power over a course of year is obtained when the tilt angle is equal to the latitude of the location." (Sun Incident Angle and Position Effect 2009) Figure 22 displays a simulation of "the maximum number of solar insolation as a function of latitude and module angle". (Sun Incident Angle and Position Effect 2009). Darwin has latitude of -12˚. The following describes the parameters for Figure 22:

- "Module power – is the solar radiation striking the tilted module
- The incident power is the solar radiations perpendicular to the sun's rays
- Power on the horizontal is the solar radiation striking the ground" (Sun Incident Angle and Position Effect 2009)

The module power is required to be as close as possible to the incident power. This is achieved when the array tilt angle is at 18˚. The actual power follows a sinusoidal like pattern; this is a result from the variation of radiation with the seasons. "These values should be regarded as the possible values at the location as they do not include the effects of cloud cover. The module is assumed to be facing north in the southern hemisphere." (Sun Incident Angle and Position Effect 2009)

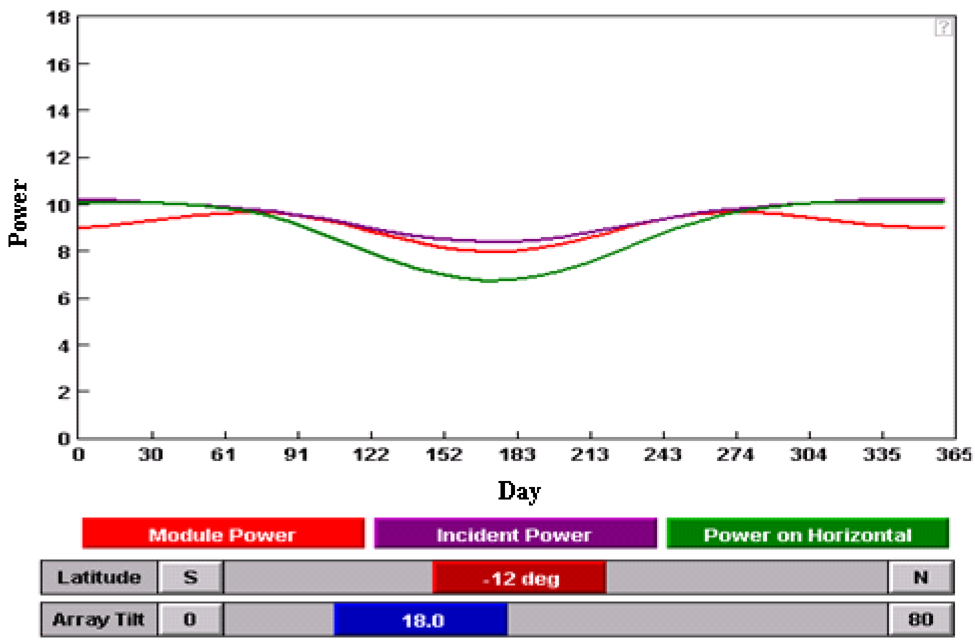


Figure 22: Array Tilt

Now using the NSOL software, Figure 23 shows that the array tilt works most effectively at 20 degrees. The BSOC is above 99% for most of the year.

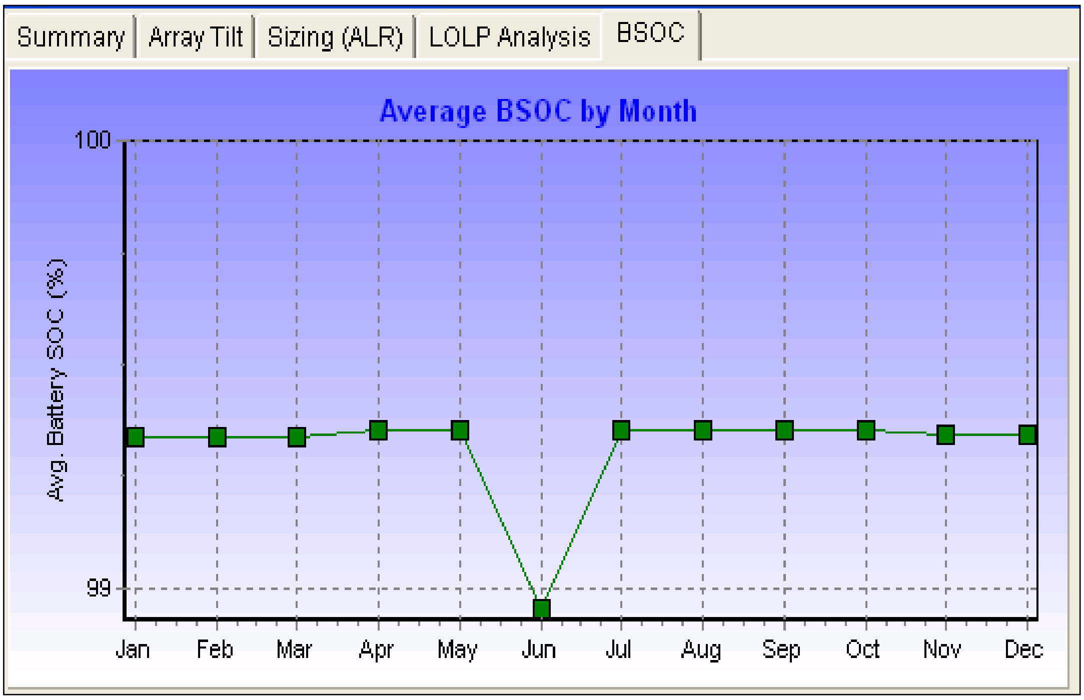


Figure 23: Average BSOC with Array Tilt of 20 degrees

Overall, the results prove that an angle between 17.5 – 20 degrees is most effective for the system.

9.4 Communications

9.4.1 Clients Requirements

The contractor is required to provide new radio equipment. The relocation, re-alignment and RF survey along with any programming requirements shall be carried out by the contractor. This includes equipment, masts and enclosures as included in the work area breakdown.

9.4.2 Communication Overview

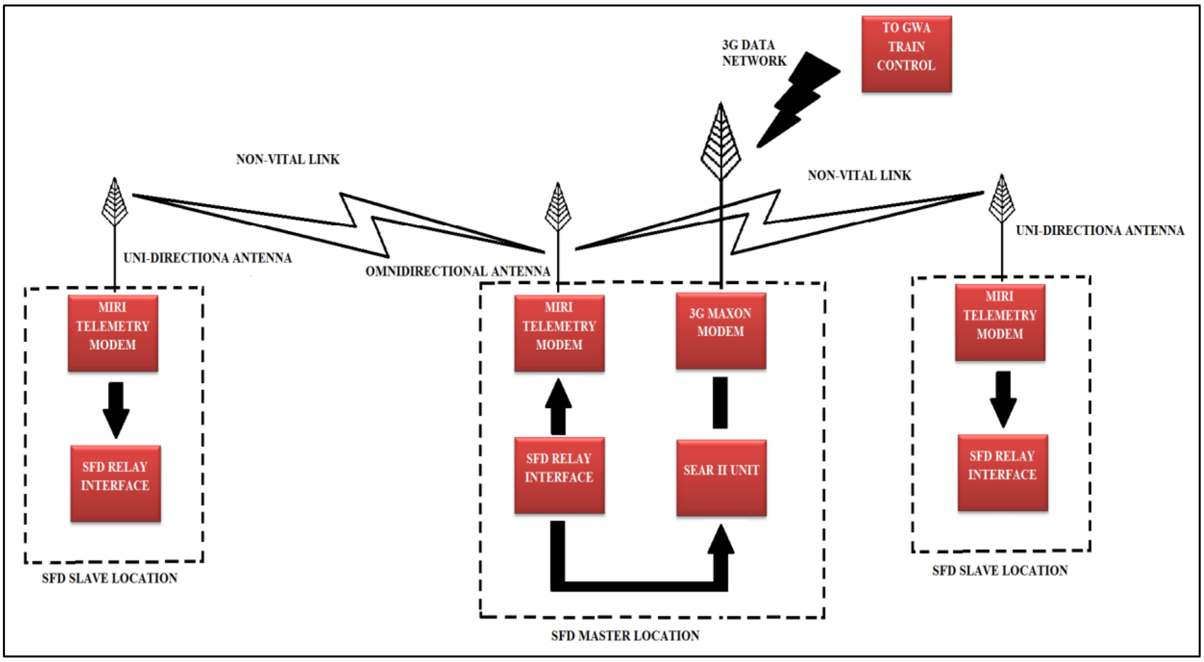


Figure 24: Communication Arrangement

Figure 24 displays the arrangement of the communication connections between the sites. The 3G Modem provides a non-vital link to the GWA train control by initiation from the SEAR II unit, whilst the Miri Telemetry Modem provides non-vital communication between the sites to determine the aspect on the indicator using relay interface. A non-vital link is described for a connection that does not involve the integrity of interlocking. Since GWA does not use interlocking, this entire system is regarded as non-vital.

Within the communication arrangement, the SFD sites are referred to as the master sites, whilst the indicator sites are referred to as the slave sites.

9.5 Telemetry Radios

The Miri AD2006 Telemetry radios (Figure 25) are the means of digital communication between the sites; they transfer information that determines the assignment of the indicator. The Miri Telemetry module "incorporates PLC functionality by way of IEC61131 standard Ladder Diagram." (telemetry and Control Solutions n.d.). Miri Technologies provide the radio fully programmed and tested.

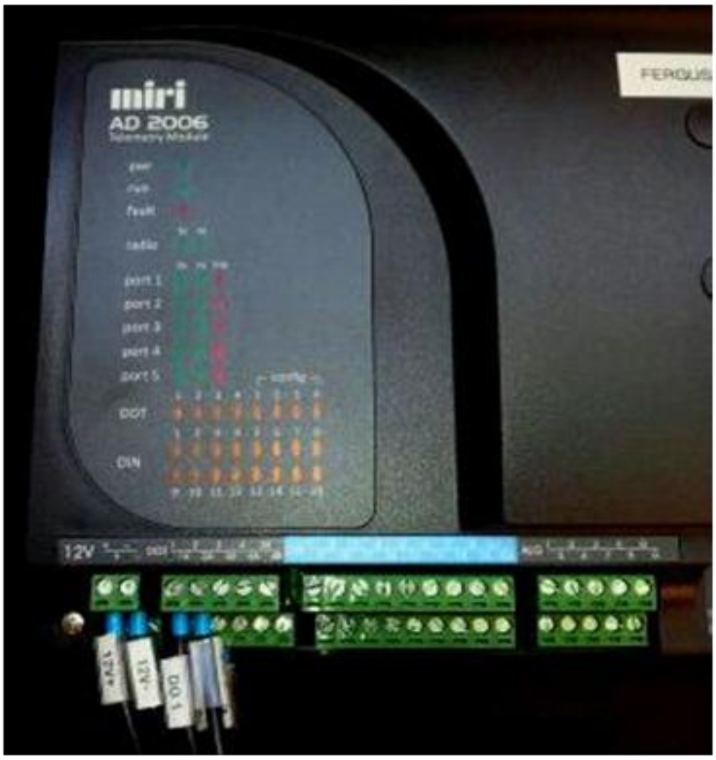


Figure 25: Miri Telemetry Radio (Image taken on 10/01/2013)

Figure 26 displays the telemetry radio system; each system consists of a master and two slaves. The system is programmed to have its own frequency to ensure a robust system; therefore the master can only communicate to its two assigned slaves and provides an independent system for each river location. It also enables better security, for example if a master radio is placed at the wrong location it will not communicate with the surrounding slaves. In addition, Cullen, Fergusson and Edith River are located within close proximity to each other and the slaves are not required to detect alarms from other river locations.

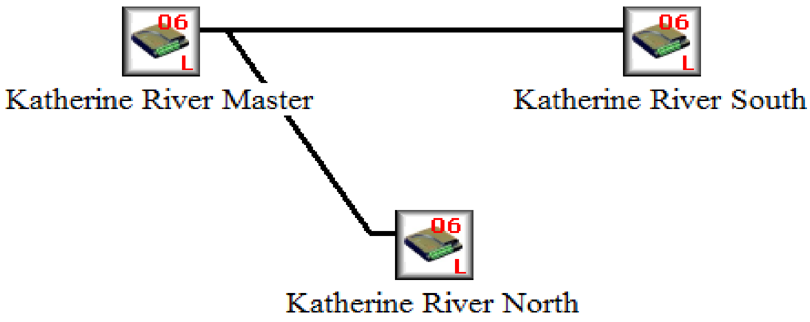


Figure 26: Telemetry radio system

The frequencies that are used for each location are demonstrated in Table 12.

Table 12: Site Frequencies

Site Frequencies		
Location	Tx Frequency (MHz)	Rx Frequency (MHz)
Elizabeth River	471.950	471.950
Adelaide River	472.00	472.00
Cullen River	471.275	471.275
Fergusson River	471.950	471.950
Edith River	471.575	471.575
Katherine River	472.00	472.00

Table 12 shows that Adelaide River and Katherine River have the same transmit and receive frequencies. This is not an issue because the sites are 287.96 km apart and will not interfere with one another.

Miri Technologies designed the radios to use a baud rate of 4800bps because low baud rate results in better signal strength. The radios are programmed to poll each other every 10 seconds. 10 seconds is the polling rate instead of continuously polling because there will be a long periods of time where the information does not change. The packet for each poll includes:

- Digital I/O (1)
- Analogue I/O (8)
- RSSI(1)

9.5.1 Design

The Miri-telemetry system located in the master location case is provided with two digital Inputs. This information will be transferred to Miri-system at the slave location, in which, energises two outputs to the relays. To ensure fail–safe functionality during communication break, the outputs of the Miri-system at slave location have to become low during failure conditions. The connections for the master and slave connections are demonstrated in Figures 27 & 28.

Master

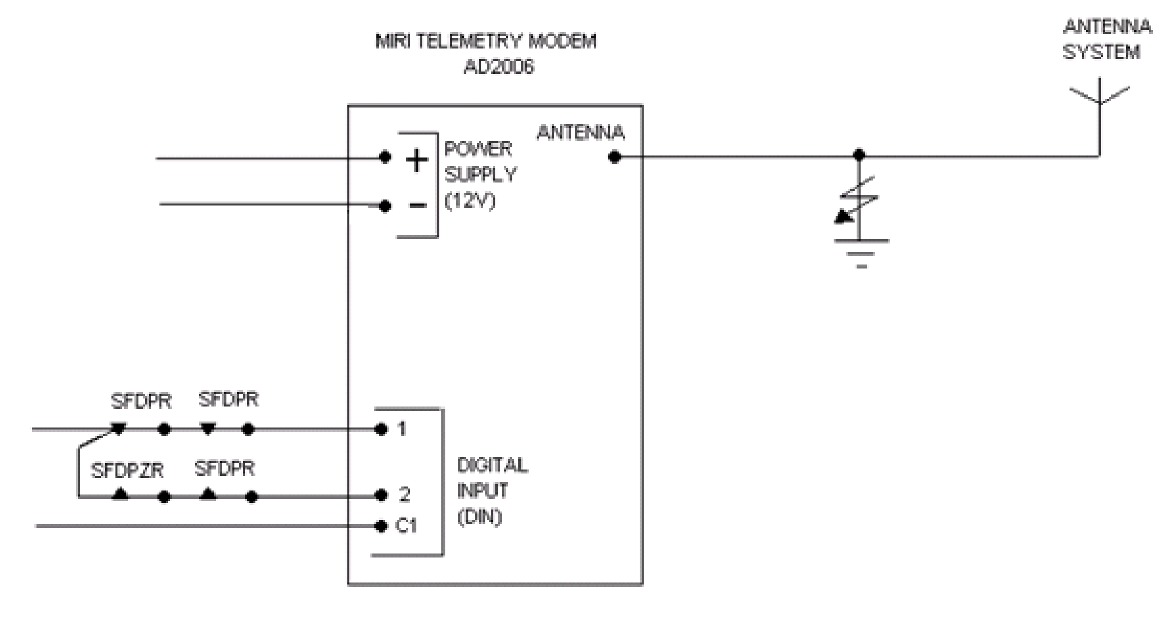


Figure 27: Master Miri Design

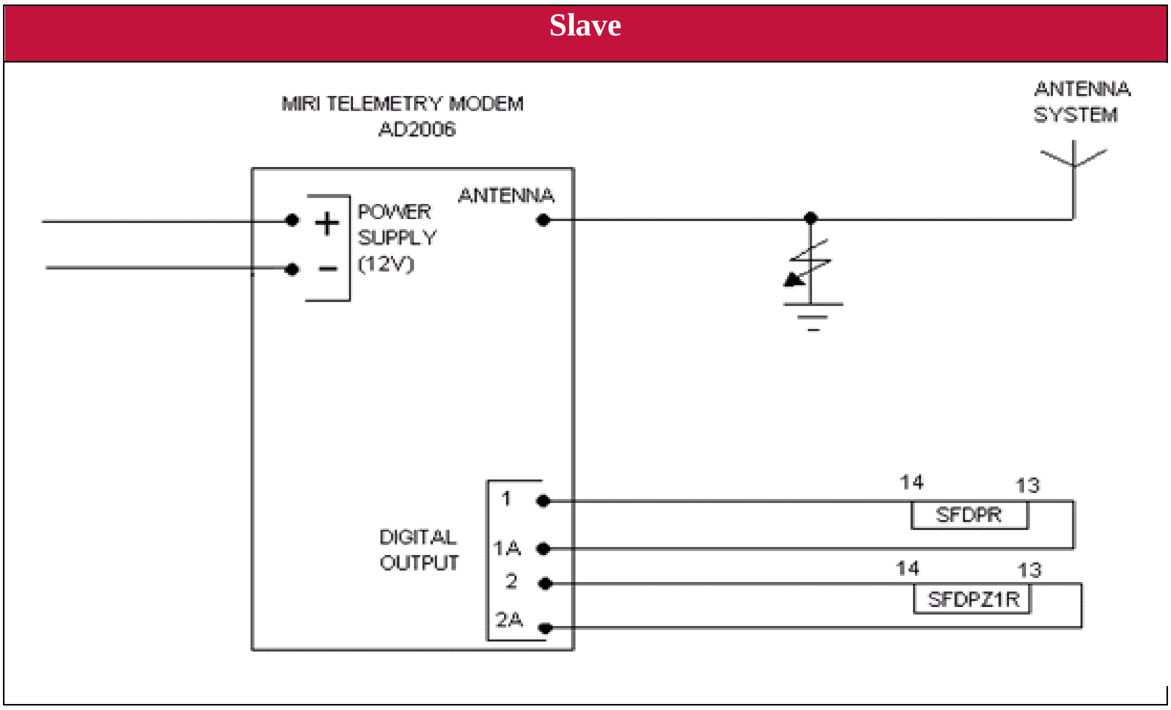


Figure 28: Slave Miri Design

The original design involved only one input and output; however, Independent Reviewer (Mark Dunning) incorporated the use of two inputs and outputs to ensure extra safety in case one of the inputs failed. The relays drive the aspect on the indicator; therefore, if the Miri radio failed to operate, the indicator will result in a blackout. A table to explain the function of the relays is located in Appendix B.

The antenna system is earthed because it is exposed. The Miri telemetry modem is not earthed because it contains a DC/DC converter inside the modem. This will provide isolation.

9.5.2 Antenna System

The Antenna system is a transmission device to "allow radio-frequency communication between distant locations across empty space or other material media" (Chen 2005). It was instructed that all Master sites have a single dipole antenna and 6 element Yagi antennas at the slave sites. The single dipole antenna "provides omnidirectional radiation pattern" (Side Mount Dipole Antenna 2012) and are therefore typically used at "Master Stations" to communicate with remote sites in all directions. The 6 element Yagi "are high gain antennas which provide excellent point to point communication in RF control" (UHF Yagi 2012). The yagi antennas have a driven element which is essentially a dipole as is the base station antenna, but the gain is concentrated in one direction by the ‘directors’, which are the elements in front of the driven element. The directors are proportional to the gain, hence the six element yagi “exhibit narrow beamwidths and high front to back ratios to help minimise potential interference to and from other systems” (UHF Yagi 2012). Figure 29 displays the installation requirements for both antennas.

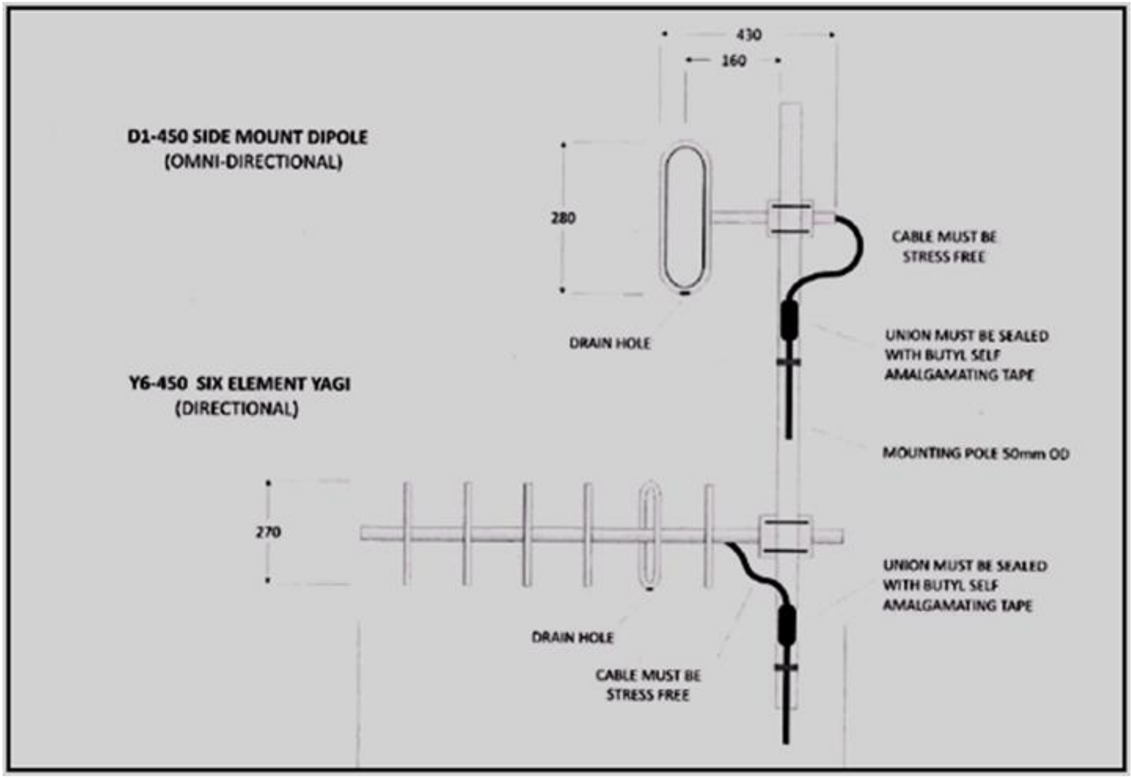


Figure 29: Antennas (Image from AD2006 Quickstart Manual 2012)

9.5.3 Telemetry Field Survey

A radio survey was conducted on 23/10/12 – 26/10/12 to verify that reliable radio based telemetry can be confirmed at all six (6) sites of the SFD monitoring system. Figure 30 shows the execution of the field survey.

Figure 30: Radio Survey (Image taken on 24/102012)

Weather conditions were fine and around 37°- 41° C, with high humidity and virtually no wind. Testing was performed using a single Side Mount Dipole antenna (unity gain) at the Master Sites and a six element Yagi antenna (9dB gain) at the remote sites, 5 meters of RG213 cable and 2 meters of RG58 cable was used between the antennas and the AD2006 Telemetry units. Frequency is 472MHz. Extension poles were used to raise the antennas to approximately 3.5 meters above ground level. The Telemetry units were set to +30dB (1 Watt) transmit and their receiver was muted at -110dB. The units were programmed to continuously poll each other and a variable (stepped) attenuator was then used to increase attenuation to the point where signal was no longer available. The resulting figure is the Fade Margin in dB, this is essentially the amount of 'spare' RF signal maintained over the radio units minimum receive level and is required to compensate for difficult weather conditions and other factors which can attenuate the available RF signal. Miri Technologies recommend a minimum of 20dB of Fade Margin for sub 15km paths at UHF.

The locations tested varied somewhat from the actual locations due to absent markings for the indicator sites, a careful estimation of 2500m from the river was executed and these new locations were used in the desktop survey and were recorded along with the signal results in Table 15. The minimum proposed antenna height is 6 metres and this extra 2.5 metres of antenna height over the surveyed antenna height will distinctly improve the available signal in all cases.

9.5.4 Theoretical Calculations

The theoretical calculations are used as a reference to compare against the results of the survey. The link margin illustrates the performance of the equipment. It is determined using the following parameters:

Where

- TX power = Transmit power = = 30dBm
- TX ant gain = The transmit antenna gain = 1dB
- RX ant gain = Receive antenna gain = 9dB
- Min RSL = Minimum received signal strength = -110dBm

$$L_{margin} = TX_{power} + TX_{ant\ gain} + RX_{ant\ gain} - Min\ RSL$$

The equation becomes:

$$L_{margin} = 30 + 1 + 9 — (-110) = 150dB$$

The loss of free space is also required to be calculated, it is a result of the wavefront radiated signal as a function of the distance from the transmitter. It is the line-of-sight path through free space, as demonstrated in Figure 31.

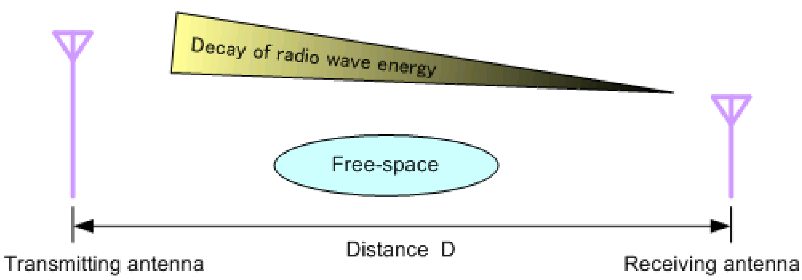


Figure 31: Attenuation in Free-space (Radio Technical reference Design Guide 2012)

The RF signal may be absorbed when it passes through solid objects and so attenuation needs to be factored in. To incorporate these losses into the equation, it can simply be added to the Free Space loss as miscellaneous loss. There are three factors that affect attenuation:

1. Trees account for a max of 20dB loss per tree in the direct path. Loss depends of the size and type of tree, for example, large trees with dense foliage create greater loss.

2. The RG213 Coax cable which is utilised in this design has approximately 5dB of loss per 30m at 450 MHz

3. The connector loss is around 1dB for all the coax plug connections.

The free space loss is calculated by:

$$L_{fsl} = 10\ log_{10}\ ((\frac{4\pi}{c}df)^2)$$

$$L_{fsl} = 20\ log_{10}\ (\frac{4\pi}{c}df)$$

Where:

- c – speed of lights in a vacuum (kms^{-1})
- d – the distance from the transmitter (km) = 2.5km
- f – signal frequency (Hz) = 472MHz

Equations are from (Free-space path loss 2012). To calculate the free space in decibels, the equation becomes:

$$L_{fsl} = 20\ log_{10}(d) + \ 20\ log_{10}(f) + \ 20\ log_{10}\left(\frac{4\pi}{c}\right) + L_{misc}$$

$$L_{fsl} = 20\ log_{10}(d) + \ 20\ log_{10}(f) - 87.958 + \ L_{misc}$$

$$L_{fsl} = 20\ log_{10}(2.500) + \ 20\ log_{10}(472\ x10^6) - 87.598\ +\ 26$$

$$L_{fsl} = 7.958 + 173 - 87.598 + \ 26$$

$$L_{fsl} = 119.36dB$$

The fade margin is calculated by:

$$L_{fade\ margin} = L_{margin} - L_{fsl}$$

$$L_{fade\ margin} = 150 - 119.36 = 30.64 \text{ dB}$$

The theoretical result satisfies the requirement of having a minimum fade margin of 20 dB. (Free-space path loss 2012).

9.5.5 Field Survey Test Results

The field survey results are recorded in Table 13.

Table 13: Survey Results

	Site Latitude	Site Longitude	Fade Margin
Elizabeth River			
ELR Master	12 32 14.0 S	130 58 43.6 E	
ELR Slave No1	12 33 25.0 S	130 58 02.4 E	33dB
ELR Slave No2	12 31 05.2 S	130 58 00.8 E	29dB
Katherine River			
KR Master	14 29 46.7 S	132 13 53.7 E	
KR Slave No1	14 30 41.6 S	132 15 02.5 E	31dB
KR Slave No2	14 28 50.6 S	132 12 51.4 E	25dB
Adelaide River			
AR Master	13 14 29.3 S	131 06 30.5 E	
AR Slave No1	13 15 03.2 S	131 07 45.3 E	26dB
AR Slave No3	13 13 12.8 S	131 05 57.2 E	16dB
Edith River			
EDR Master	14 11 04.3 S	132 02 16.2 E	
EDR Slave No1	14 12 26.0 S	132 02 47.4 E	29dB
EDR Slave No2	14 10 01.2 S	132 01 17.0 E	36dB
Cullen River			
CR Master	14 01 55.5 S	131 56 39.4 E	

CR Slave No2	14 03 06.4 S	131 57 48.7 E	27dB
CR Slave No3	14 00 35.0 S	131 56 10.6 E	25dB
Backup Creek			
BC Master	14 04 28.3 S	131 58 55.9 E	
BC Slave No1	14 05 32.8 S	131 59 24.5 E	30dB
BC Slave No2	14 03 29.8 S	131 58 00.9 E	29dB

Testing indicated that two of the systems require additional Master antenna height;

1. **Katherine River** –The location of the proposed antenna mast is approximately 3-4 metres high because the site is below track level, the readings recorded in the above table were taken at track level. The Signal level was considerably reduced at the proposed antenna site.
2. **Adelaide River** – Due to the track curving around the hill just north of the Snake Creek the actual Adelaide River Slave site is significantly obstructed and was the only site in this survey to return a reading below the minimum 20dB recommended Fade Margin.

To improve the system reliability Miri Technologies recommended the use of 10m Master site masts at the Adelaide River and Katherine river sites at a minimum and if feasible at all master sites. Management have agreed to install a 10 meter antenna pole at Adelaide River and Katherine River, a 6 meter antenna pole will be installed at the additional sites.

In regards to the theoretical calculations, the results from the survey are very close to the theoretical result (29.13dB). Discrepancies in the field survey results may include:

- Extra attenuation from obstacles, including trees - the theoretical calculation included one tree; however, this value may vary in reality.
- Increased/decreased loss in the equipment – although 6dB was added to account for the 5dB cable loss and 1dB connector loss, it was still an approximate value, and hence, the miscellaneous loss may also vary slightly.

9.5.6 Recommendations

The increase in height of all antenna poles may increase the size of the footings which may ultimately result in extra cost from labour, machinery and materials. Although the minimum amount of spare RF signal is met at most sites, I still recommend following Miri technologies advice as a 10 meter antenna pole at all sites will guarantee a signal between the sites. Furthermore, the money that may be saved by using only two solar panels at indicator sites may compensate for the extra expense of installing a 10 metre antenna pole at all sites.

9.5.7 Programming

The Miri telemetry modem is pre-programmed; it is developed by Miri technologies programming engineer Bill Nicol using ladder logic. The digital inputs are connected to a timer which requires the digital input to be high for ten seconds before initiating an output to the slave. The programming also incorporates health bits to ensure that the Miri is operating correctly before sending out any alarms. This is demonstrated in the Figure 32.

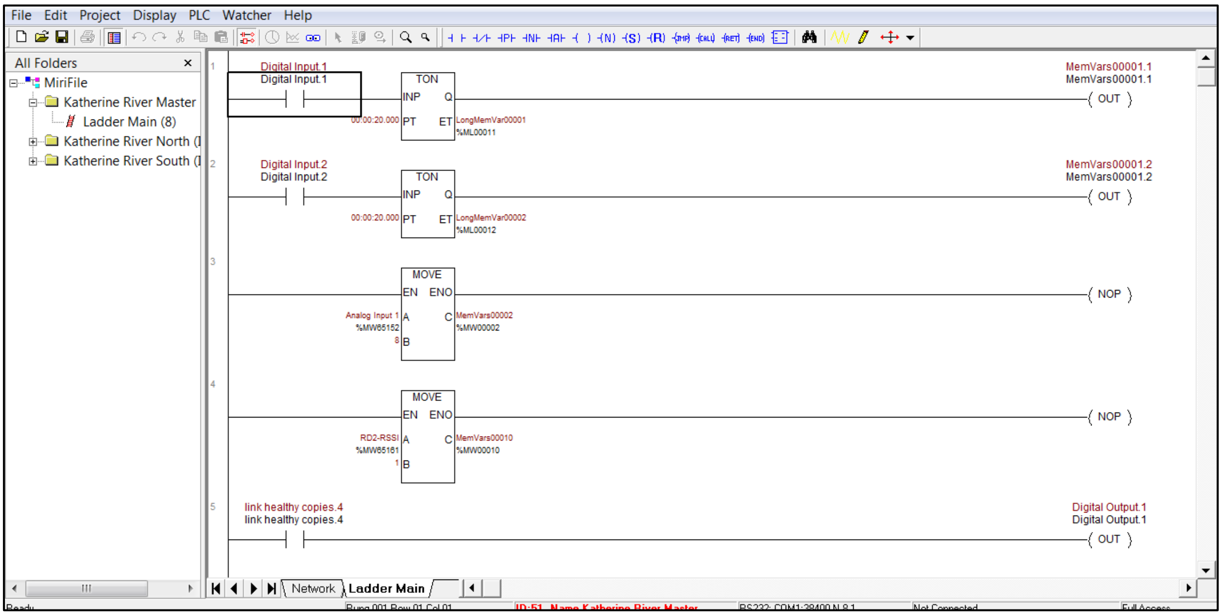


Figure 32: Miri Programming (Katherine River Master)

9.5.8 Licensing

The applications are reasonably critical, therefore, the option chosen for the radio channels and licensing is the Licensed 450 MHz; this will provide the most robust RF performance and immunity from potential interference

Using the licensed 450MHz equipment provide a 9600bps bandwidth in 12.5kHz ACMA channel assignment and the standby current drain of the Miri AD2006 unit & radio would be in the order of 200mA. Miri Technologies takes care of all the necessary paperwork.

9.6 SEAR II

The SEAR II is “a modular event recording and analysing system” (SEAR II Datasheet). It offers an inclusive controlled alarm management system for Railway Signalling, effectively, reducing the cost of manual inspection and providing the ability to be immediately aware of any alarms.

Figure 33: SEAR II (image taken on 06/01/2013).

“Its embedded standard or customised logic monitors every change of state on each of its inputs to positively discriminate between normal operation and system faults. Every change of state is logged and time stamped and stored in non-volatile memory. Alarms and key states can be displayed locally or sent to a remote centre” (SEAR II Datasheet). For this project, the SEAR II will monitor the following inputs:

- Power supply input – This input monitors the power supply for the system. It monitors the solar panel and battery outputs.
- SFD digital input – This input is a basic digital input that monitors the state of the SFD.

To generate the following alarms:

- Power supply alarm
- SFD alarm

Table 14: SEAR II Connections

Figure 34 illustrates the SEAR II connections; an explanation of each connection is detailed below:

SEAR II Connections

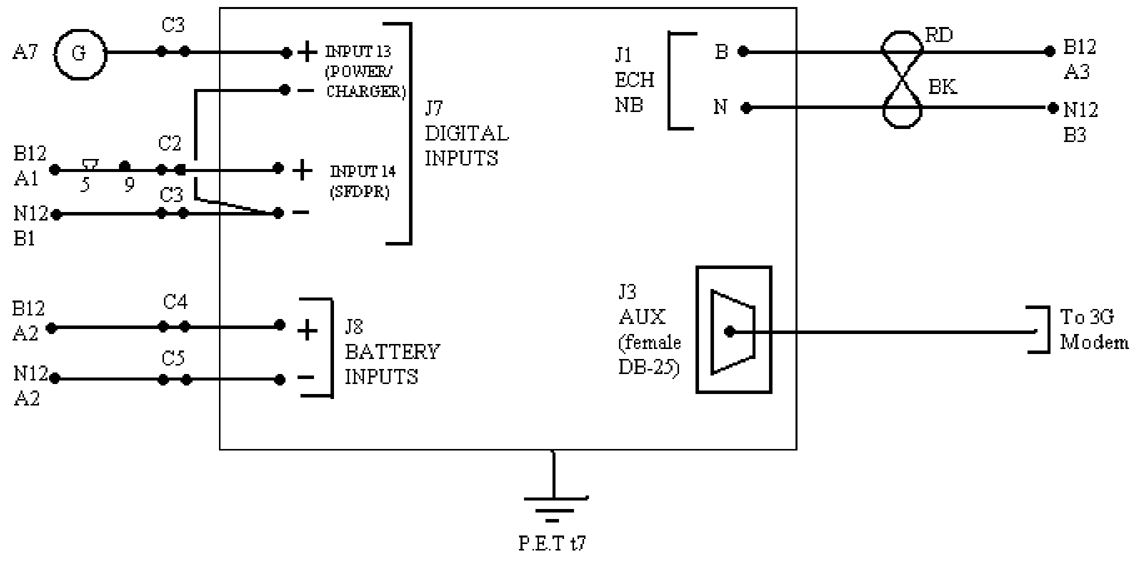


Figure 34: SEAR II Connections

- J1 is the echelon connection that powers the SEAR II; it uses a twisted pair cable at 1 turn per foot at this connection. The twisted pair enables extra protection from interference.
- J7 are the digital inputs that require one positive and one negative terminal per input. Digital inputs are monitored approximately every 10 milliseconds.
- J8 are the battery inputs, it monitors the DC batteries to ensure that an appropriate voltage is constantly supplied. The SEAR II samples this input every 10 milliseconds, however, the logging interval can be determined by the user.
- J3 provides interface for the 3G modem. It is a female 25 pin auxiliary port that is connected to a male 15 pin connection. It uses a specially designed cable that is made in the workshop. The connection provides the communication link from the alarm to the modem. The pin out connections is listed in Table 15.

Table 15: Connections between the SEAR II and 3G Modem

Cable Connections	
DB25 Male (SEAR II)	DB15 Male (Modem)
2	3
3	2
4	7
5	8
6	6
7	14
8	1
20	13
22	10

The 3G modem and the SEAR II communicate using the Genisys Protocol. "Genisys Protocol is designed for use over serial connections. The protocol enables one master to communicate to one or more slaves. Genisys is a trademark of Union Switch & Signal." (Keeler 2009)

9.6.1 Configuration Procedure

The SEAR II is provided with a SFD file that is required to be downloaded; the file contains all the relevant I/O programming that was determined between the SEAR II programmer and the Technical Supervisor (John Cole).

The SEAR II is pre-set with a baud rate of 9600 but is required to be changed to a baud rate of 57600. This particular baud rate enables a faster rate of transmission when the SFD file is being downloaded. This alteration can be achieved using a software program called HyperTerminal; the physical connection involves 9 pin serial ports to the com port between the SEAR II and the computer. The connections are identified in Figure 35.

Now, the Site Setup is to be followed, it can be accomplished using HyperTerminal or on the LUI panel. The site setup is specific to the site, and allows identification of alarms, location, current date and time. Adelaide River SFD Site is used as an example.

The Site set up can be done using HyperTerminal or on the LUI panel. Table 16 shows the sequence of the site setup procedure.

Table 16: SEAR II site Setup Procedure

Stage 1		
seq	Program Display	Selection
1.1		PRESS SITE SETUP
1.2	DATE/TIME	mm-dd-yy hr:mm:ss
1.3	AUTOMATIC DST ADJUSTMENT	NO
1.4	TIME ZONE?	OTHER
1.5	GMT OFFSET?	+9:30
1.6	SITE NAME?	ADELAIDE RIVER
1.7	MILEPOST?	2649.8
1.8	DOT#?	26498
1.9	TESTER TYPE?	WAYSIDE
1.10	DATE FORMAT	dd-mm-yy
1.11	TEMP. FORMAT	CELSIUS
1.12	INDICATE HOLD (SEC)?	10
1.13	INDICATE REFRESH (SEC)?	60
1.14	SITE ATCS ADDRESS?	7.048.110.032.99
1.15	SITE TYPE?	COLLECTOR
1.16	OFFICE ATCS ADDRESS?	2.620.00.0000
1.17	POLL ID?	1
1.18	MODE?	GEN/ATCS
1.19	WAMS XID?	ENABLED
1.20	OFFCIE COMM DEVICE?	Dial Modem (RS232)
1.21	Dial Modem (RS232) PORT?	AUX
1.22	PHONE #?	
1.23	INIT STRING?	&F1
1.24	FIELD COMM DEVICE	NONE
1.25	USER PORT BAUD?	57600
1.26	USER PORT DATA BITS?	8

1.27	USER PORT PARITY?	NONE
1.28	USER PORT STOP BITS	1
1.29	USER PORT FLOW CTRL?	NONE
1.30	AUX PORT BAUD?	57600
1.31	AUX PORT DATA BITS?	8
1.32	AUX PORT PARITY?	NONE
1.33	AUX PORT STOP BITS?	1
1.34	AUX PORT FLOW CONTROL?	HARDWARE
1.35	COMM PORT BAUD?	57600
1.36	COMM PORT DATA BITS?	8
1.37	COMM PORT PARITY?	NONE
1.38	COMM PORT STOP BITS?	1
1.39	COMM PORT FLOW CONTROL?	NONE
PLEASE WAIT ...Compiling		
Stage 2		
2.1	RESET NAMES/MODULES?	YES
2.2	STREAM FLOW DETECTOR 1 USED?	YES
2.3	STREAM FLOW DETECTOR 2 USED?	NO
2.4	MONITOR AC POWER/CHARGER	NO
2.5	MONITOR SOLAR BATTERY SOC INPUT?	YES
2.6	ENTER SOLAR OFF ALARM TIME (min)	5
2.7	ENTER SOLAR ON RECOVERY TIME (min)	2
2.8	MONITOR DC SUPPLY VOLTAGES?	YES
2.9	BATTERY INPUT 1	B12V
2.10	ENTER LOW B12 VOLTAGE LEVEL	105
2.11	ENTER CRITICAL B12 VOLTAGE LEVEL	100
2.12	BATTERY INPUT 2	NOT USED
2.13	BATTERY INPUT 3	NOT USED
2.14	SOLAR PANEL INTEGRITY ALARM?	NO
PLEASE WAIT ...Compiling		

The site type (seq 1.15) is chosen to be a collector. “The collector is the master unit in the ATCS enhanced routing protocol that has a direct link to the office system. SEAR II configured as Nodes report their alarms and status to this site. The unit then forwards the messages to the office system” (Safetran Event Analyzer Recorder (SEAR II) A80273 2010)

The Poll ID (1.17) is the Genisys protocol polling identification number for this site.

The ATCS address (seq 1.14) is a unique number given by Westinghouse (the SEAR II manufacturer) for each site. It provides identity for Manufacturer purposes. In addition, the Office ATCS Address (seq 1.16) is another unique number for office purposes.

The initialisation string (seq 1.23) is &F1 is the command that will initialise the GSM modem upon start up.

Notice ENTER SOLAR OFF ALARM TIME (min) is five minutes. This means that the Solar Battery inputs needs to be off for five (5) minutes in order for an alarm to occur. Five (5) minutes are required in order to ignore any fluctuations/spikes in the system.

Also, the Low battery Voltage level (seq 2.10) is 10.5V and the critical Battery Voltage level (seq 2.11) is 10.0V. An alarm will be generated at both voltage levels.

9.7 3G Modem

The 3G modem allows Train Control to receive text messages obtaining any important information that is logged and monitored by the SEAR II. The message includes:

- Alarm description
- Location Name
- Milepost
- Time and Date
- ATCS address

9.7.1 3G Modem Design

Figure 35 shows that the 3G modem is connected to a DC/DC Converter to provide a clean signal and extra isolation to the system. An earth bar is connected to the antenna to conform Australian standards, as mentioned previously; anything exposed is required to be earthed.

GSM Modem Design

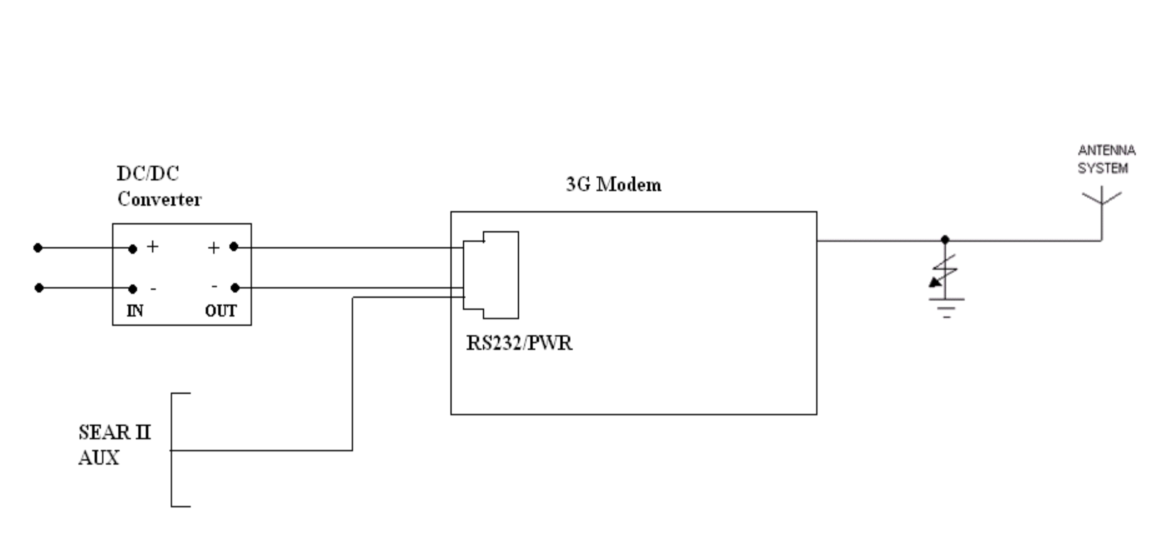


Figure 35: GSM Modem Design

9.7.2 MA-2015 modem Configuration

The 3G Serial Modem (MA-2015) is the latest version of ModMax modem. The Modmax modem is utilised in earlier ODG projects as well as this project. The configuration of the 3G Serial Modem (MA-2015) involves using Gui software and is connected to the computer com port by DB25-RJ45 Power & Serial Cable which is supplied by the manufacturer.

The advantage of using Gui Software is that only one modem is required to be configured, as this configuration can be saved and then uploaded to a new modem. Once the modem is configured, it will be able to communicate with a mobile phone through the HyperTerminal program.

However, communication to Train Control was not achieved. A series of fault finding techniques was taken, this includes:

- Testing the power connection
- Checking that the cable is working correctly

- Checking the SIM card is registered and that it is the correct sim card
- Checking that the modem is connected to the correct port
- Checking the baud rate
- Checking that HyperTerminal has the correct settings

After many discussions between the technical manager (John Cole), the supplier and the Client, it was agreed that the 3G ModMax modem would replace the 3G MA-2015 Serial modem as communication has already been previously established.

9.7.3 3G ModMax Modem configuration

A series of commands is required to initialise the 3G ModMax modem (Table 17); these commands are entered into the HyperTerminal Software program.

Table 17: 3G ModMax Modem Configuration

seq	AT Command	Description
Note - Factory Default baud rate is 115200 (Set laptop to 115200)		
1	**at&f**	Set to default
2	**at+ipr=57600**	Sets baud rate to 57600 (Reset lap top connection to 57600 to continue)
3	**at&c0**	Ignore DCD assumes always set
4	**at&d0**	Ignore DTR assumes always set
5	**ats0=0**	Turn auto answer off
6	**ate1**	Turn local echo on
7	**atq0**	Turn results code on
8	**at&w1**	Save settings to user profile 1
9	**at&f1**	Load settings from user profile 1
Other Commands		
10	**at$$rssi?**	Request RSSI signal strength level

9.8 Design

9.8.1 Design Procedure

The design procedure displayed in Figure 36 is followed for every design. More specifically to this project, the technical manager prepared the design briefing sheet. My participation was in the prepare design phase where I took the role of design assistant. This role is to check the initial design and make corrections after the review. For example, one of the corrections anticipated by the independent reviewer for the SFD sites was to add a second relay to the Miri inputs and outputs to ensure extra safety in case one of the digital I/O's failed. When the checker is satisfied that all logs have been addressed the design will be delivered to the client for review.

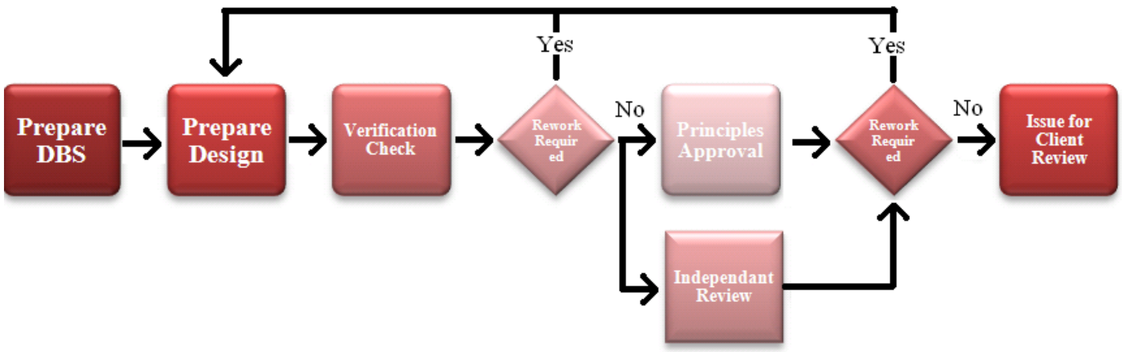


Figure 36: Simplified Design Process

9.8.2 Design Analysis

This section relates to the SFD and Indicator Site designs. Cullen River SFD site is located in Appendix G; it can be followed along with the sections below to help explain the design analysis. Note: the same designs are repeated for the remaining standalone sites.

9.8.2.1 Site and Location Case Layout

This sheet (see appendix G, sheet 002) details the schematic interpretation of the site layout across all three sites. The site layout is useful at the beginning of the document because it describes the overall concept of the project. It also displays the layout of the equipment within the LOC which guides procurement, fabrication and testing departments to achieve the desired outcome, effectively the designers, testers and associated people can verify that LOC and Site are built as per the design.

9.8.2.2 12V Solar Power Connections

This sheet (see appendix G, sheet 003) details the power supply arrangements. For the SFD Design, the solar array consists of 3 banks of 24V, 195W Suntech solar panels in series. Figure 37 demonstrates the power flow and protection measures within the design. A solar array disconnection box is designed between the solar panels and the circuit breaker to isolate the circuit. It allows changes to be made either on the solar panels or in the circuitry without needing to alter the entire circuit.

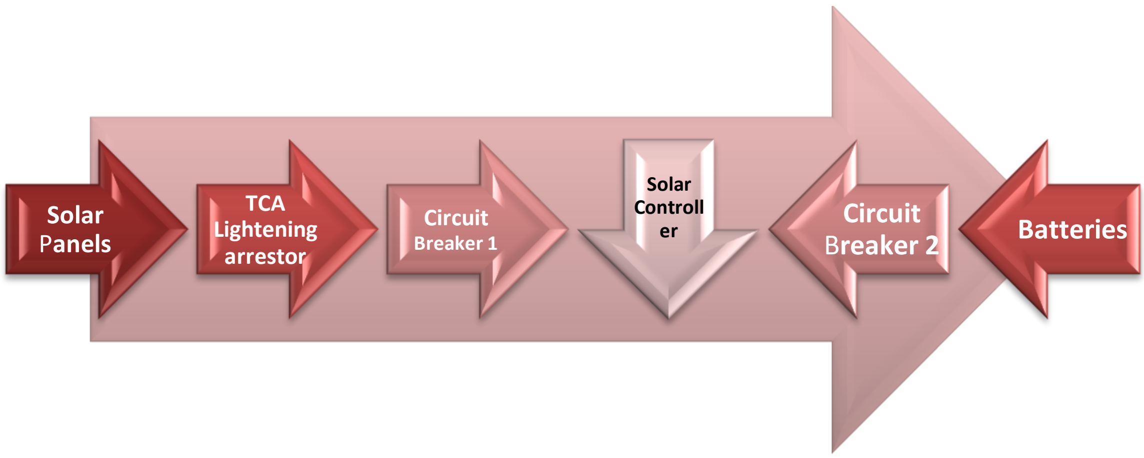


Figure 37: Power flow and protection measures.

The cable from the solar array to the transient clamp lightening arrestor (TCA) is H+S Radox Smart cable with a diameter of 4.0mm², this cable is supplied by the Solar panel manufacturer and is used because it is able to handle large currents and the thick cable minimises the voltage drop.

The TCA 1 (TC-150/802 WE) is used as a protection mechanism from lightening and allows a direct path to Earth. A circuit breaker (S202/C10) is installed after the TCA. It is another safety mechanism in the circuit; it will protect the equipment within the LOC as it will break when large surges occur. It also allows the manual action of stopping the power supply. This may be utilised in circumstances where work is required inside the LOC. The cable used between these components is 2 cores 7/1.04mm.

The Xantrex Solar controller (XW-MPPT60-150) is located after circuit breaker 1. The Xantrex controller is capable of controlling and monitoring the voltage and current. It is able to deliver the maximum available power (MPPT) from the solar array to the battery bank by “varying the ratio between the voltage and current” (Increase Solar Charging With An MPPT Power Tracking Charge Controller 2010). Hence why the solar array can be connected in series to have a 72V input and provide a 12V output. Other features include:

- Its ability to provide power directly to the equipment when the battery is fully charged.
- At night time the solar panels act like a diode in the circuit because there is no sunlight. The Xantrex controller is able to disconnect the inputs and use power from the batteries to encourage a steady source.
- The use of the battery temperature sensor (BTS) to monitor the heat. Heat and current are directly proportional; when the batteries get too hot the Xantrex Solar Controller will reduce the current output. The battery Temperature Sensor is directly connected to the battery and uses its own connector cable that is provided by the supplier.

The Auxiliary output of the Xantrax Battery Controller is connected to the PFR relay (see Appendix B for relay description). The relay is connected to a battery monitor indicator to indicate that the Xantrex Battery Controller is in working operation. It is also connected to the SEAR II power/charger input to be monitored.

Circuit breaker 2 (S160-NJ-3-160, 160A) is connected between the Xantrax Controller and the batteries (330Ah cells, Sonnenschein batteries). However, circuit breaker 2 requires 160A to break; therefore, this circuit breaker will act as an isolation point rather than a circuit breaker. It is utilised because of availability and time limitations. This is not the case for the Indicator locations; circuit breaker 2 is an ABB S202/C10 and is more effective because of its lower current breaking. The outputs of the Xantrex controller are connected to the bus bars. The bus bars now provide the main power connection for the remaining equipment within the design.

9.8.2.3 SFD Circuit

Again, the SFD uses a similar format as the Figure 38, (see appendix G, sheet 008). The SFD is located outside the LOC, therefore, surge protection is required and a junction box would be useful. The SFD determines the relay logic which is then monitored by the Miri telemetry radio and the SEAR II.

9.8.2.4 Fuse, Terminal and Contact Analysis

This sheet (see appendix G, sheet 007) provides information for the terminal connections and relays. Each terminal is numbered and labelled accordingly to provide easy readability and correct identification. Spare terminals are always incorporated in the designs to allow room for future expansion.

9.8.3 Recommendations

I suggest the following recommendations to improve the design:

- **Add a DC/DC converter** – By adding a DC/DC converter after solar panels to provide a clean signal to the system as a whole rather than just for the GSM modems.
- **Use a lower CB** - Change CB2 to break at a current that can realistically be reached. The safety rating for a circuit breaker is to break at 80% of the maximum load (Circuit Breakers 2011). Table 18 demonstrates more realistic breaking currents.

Table 18: Circuit Breakers

	Actual Circuit Breaker 2	Maximum current from the battery	Appropriate Circuit Breaker 2
Indicator Site	63A	13.2A	16.5A
SFD Site	160A	19.8A	24.75A

- **Relays -** Use extra SPARE contacts for the relay from the SFD. This will not require any cost and will ensure extra security in the circuitry.

Unfortunately, the recommendations were not implemented in the project due to time restriction.

9.9 Location Case (LOC) Design

The location case (LOC) provides a storage place to contain the equipment. The design of the LOC was influenced by the following factors:

1. **Weight.** The LOC needs to support the load of the equipment.
2. **The use of Space.** The LOC needs to be able to fit the equipment inside it.
3. **Availability.** The project is required to be completed as soon as possible.
4. **Cost.** The cost of the equipment was taken into consideration.

The dimensions of each component and installation requirements are examined to determine the LOC. Figure 38 shows the single LOCs that are utilised in this project.

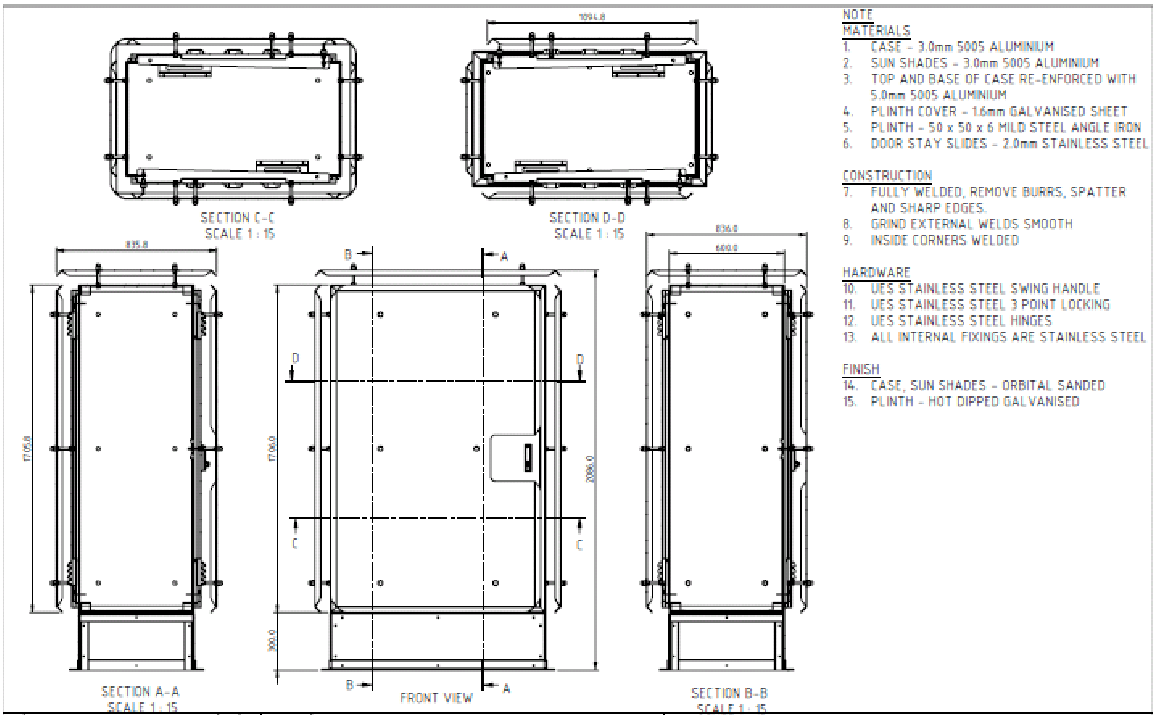


Figure 38: Single LOC

This LOC provides the following advantages:

- It is made of aluminium; aluminium is highly corrosion resistant and has excellent heat transfer properties.
- It has sun shields to further protect the equipment from heat.
- It provides access to the front and rear of the LOC
- It has a plinth for access to cables and conduits
- The plinth and the LOC are separated to prevent ingress of dust and vermin.
- The chosen LOC has been used in previous projects, therefore, specifications of the LOC are already accessible and contact with the suppliers has already been established.

- A single LOC is preferred as opposed to a double LOC because it is cheaper.

The initial design inside the location consisted of two shelves to support the batteries, a 19 ½ inch section to mount the SEAR II and the rest of the equipment to be situated around it. This design is demonstrated in Figure 39.

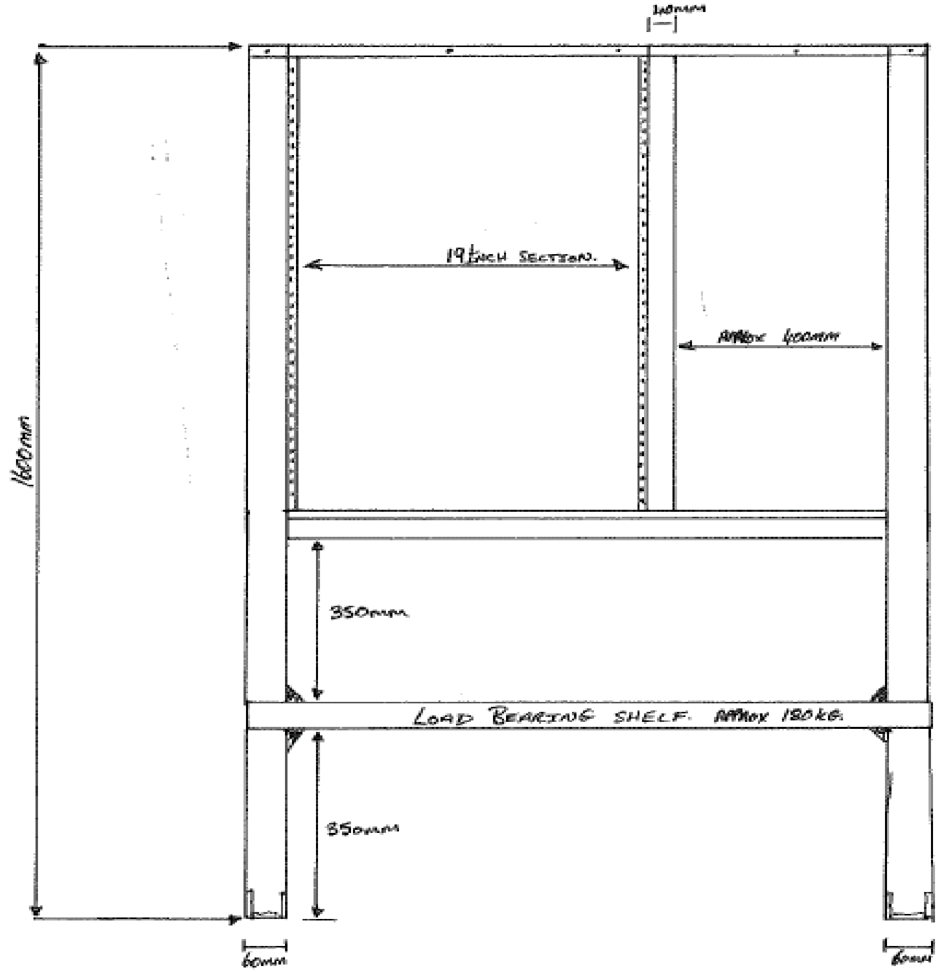


Figure 39: LOC Frame

The Power Calculations determined that six batteries is the maximum number of batteries and each battery weighs 48kg; therefore, the LOC is required to hold 288kg of battery weight.

A steel frame is inserted inside the location case to facilitate the weight of the batteries; each shelf will be able to hold a maximum of 4 batteries. The frame outlines the inside dimension of the LOC to provide maximum space and will need to be inserted by removing the side of the LOC. Figure 40 displays the layout of the battery frame.

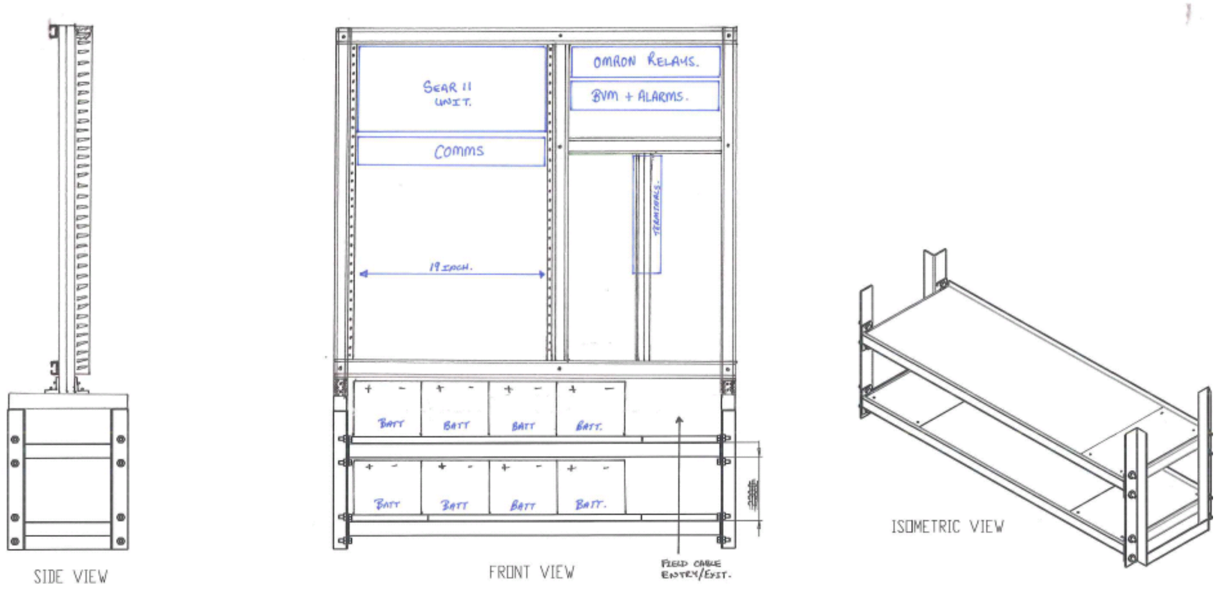


Figure 40: Layout of the LOC

The top of the LOC is designed to be made from unistrut. Unistrut is made from aluminium and can be made accordingly within the workshop to meet layout requirements. The final SFD LOC design is displayed in Figure 41.

SFD LOC

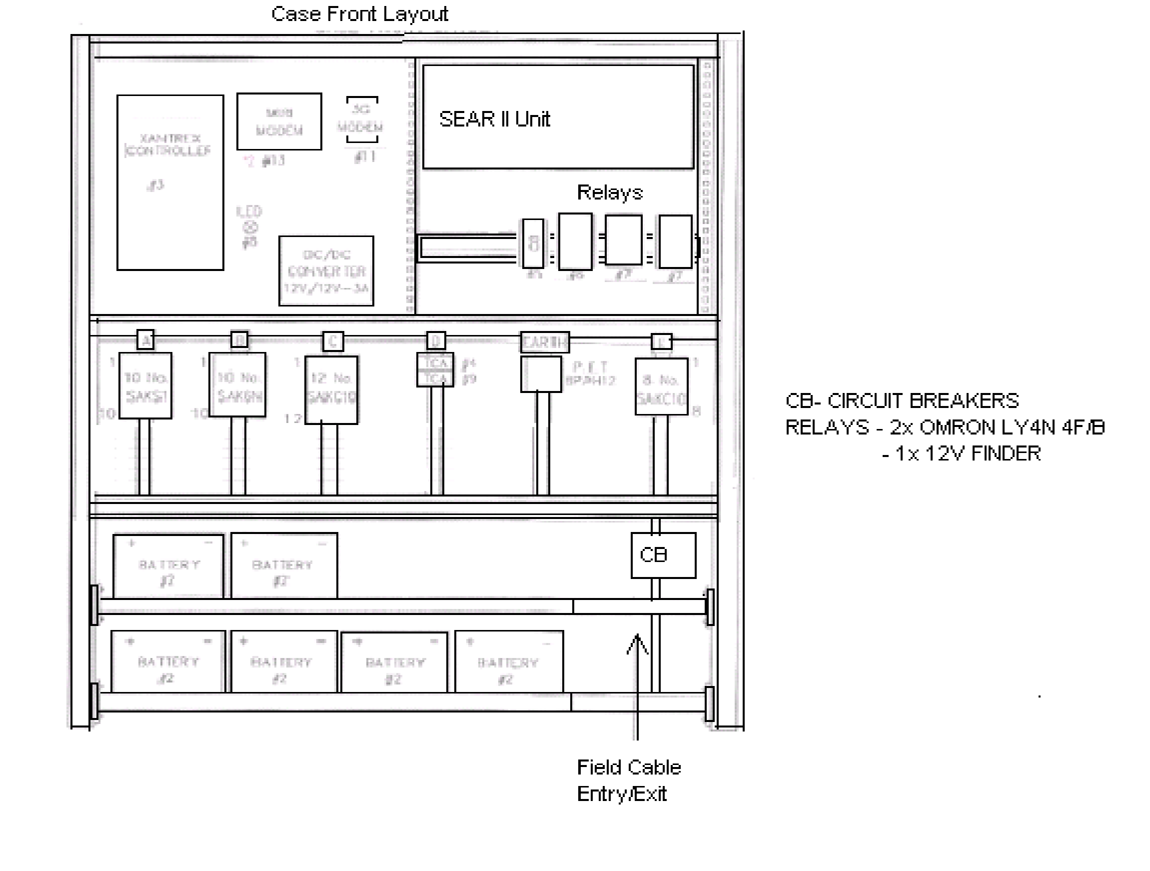


Figure 41: SFD LOC Design

The LOC has six short terminals that go across the entire width of the LOC. The positioning of the terminals is displayed Figure 42.

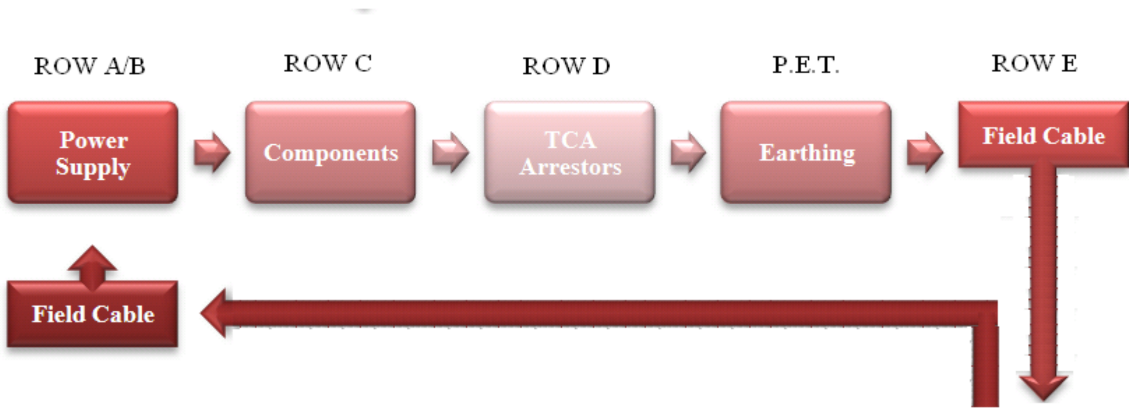


Figure 42: Terminals

The input power is placed at the beginning of the row in row A and B. Row C consists of the connections from the components within the circuitry. The TCA arrestors are placed on row D which is directly next to the earthing for easy wiring. Row E is for field cables and is positioned above the cable entry/exit.

The relays are very small in size and are situated under the SEAR II. Circuit breaker 1 is situated with the batteries because of its large dimension and the space within the LOC is limited.

The same layout will be followed for the Indicator sites as standardising the LOC improves the efficiency of construction; it enables bulk orders for the frames, LOCs and other equipment and the advantage of designing and approving only two separate layouts. The design for the Indicator SFD is shown Figure 43.

Indicator LOC

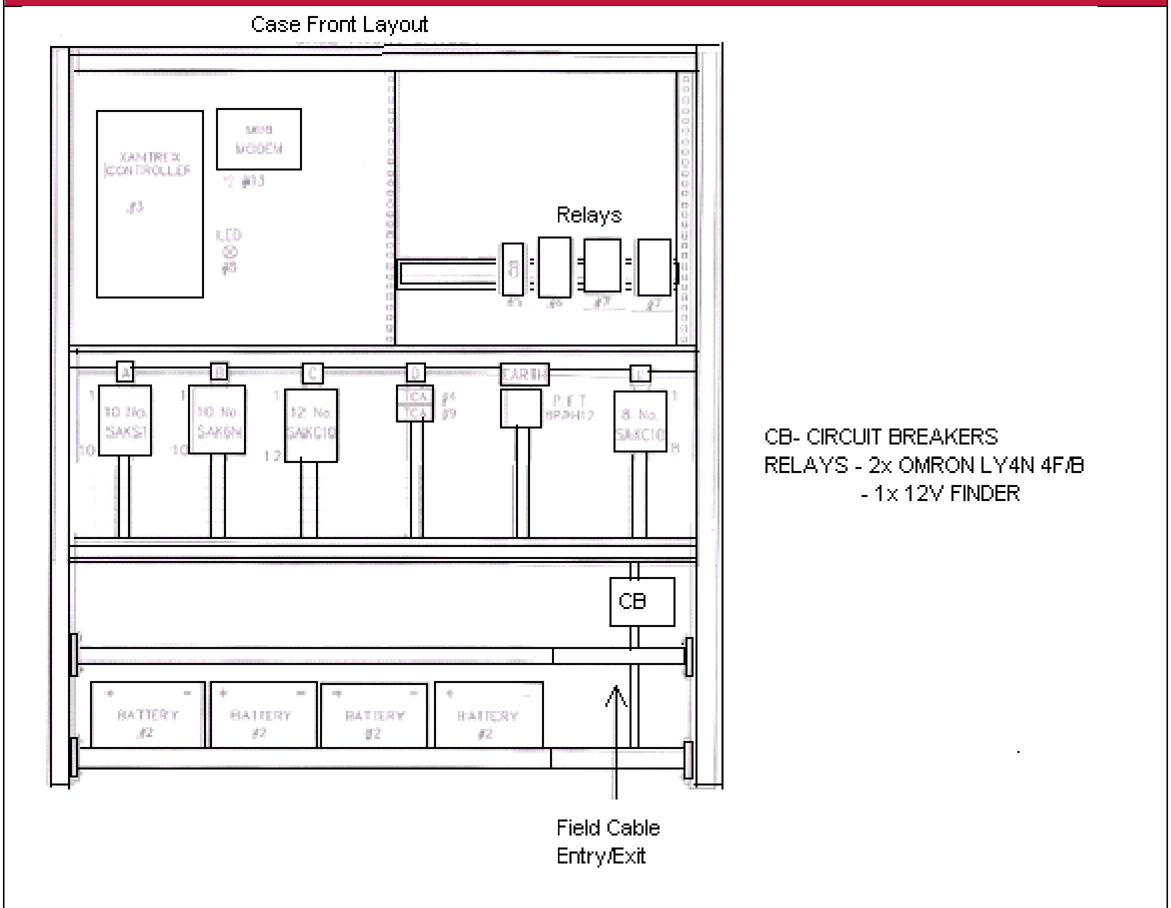


Figure 43: Indicator LOC Design

9.10 Indicator Mast Design

9.10.1 Clients Requirements

The contractor shall supply and install Westinghouse 212mm, 2 aspects Green over Yellow indicator mounted on break back masts.

All foundations shall be supplied and installed to a minimum rating of cyclonic Region ‘C’.

9.10.2 Design Strategy

ODG Haden already has approved designs for a 2 aspect indicator on a break mast that is used on previous projects. So essentially, it is only the head of the aspect that is changed. The approved design is displayed in Figure 44.

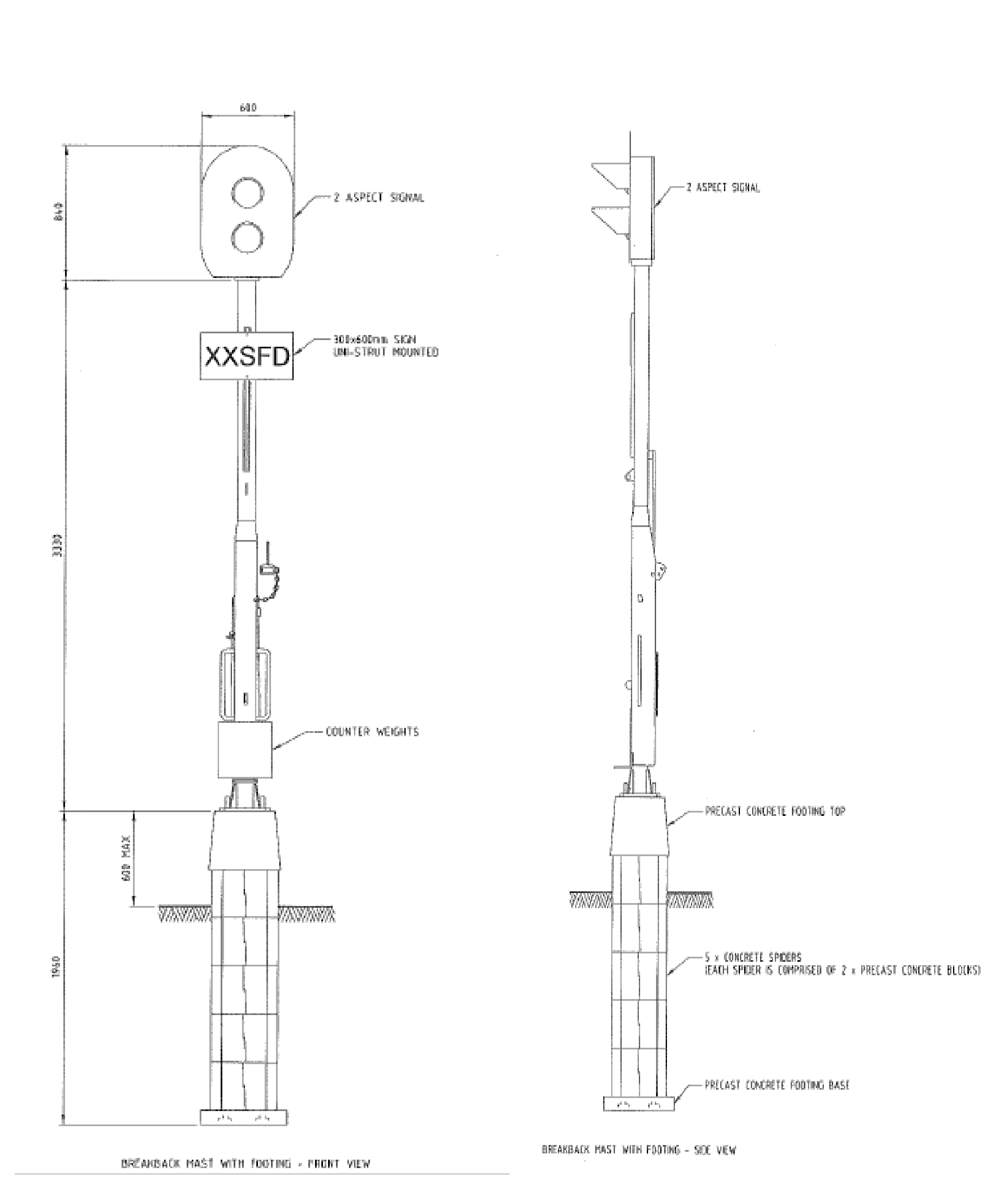


Figure 44: Indicator Design

The break back allows for easy maintenance. The footings that are required for this mast are spider footings on a precast concrete footing base. The height of the red aspect is in direct eye level of the train driver (refer to Section 8.2.1 Railway Signals). Signage for the Indicators includes the river name and the text 'SFD'. The text is on a black on reflective white background.

9.11 Solar Panel Masts Design

9.11.1 Clients Requirements

The contractor shall supply and install solar array frames (complete with solar panels). Solar panels shall be mounted on LOC roof or pole mounted with anti-theft fittings.

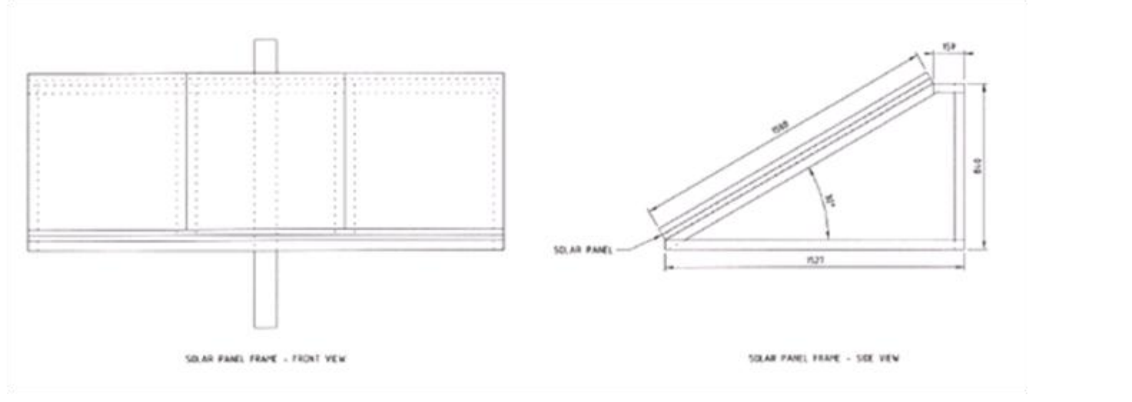
All foundations shall be supplied and installed to a minimum rating of cyclonic Region ‘C’.

9.11.2 Development

The solar panel mast design is obligated to have easy installation requirements due to poor site accessibility.

Many types of arrangement styles were discussed for the solar panels. Initially the solar panels were to be placed on top of the LOC; however, the LOC could not support the weight of the solar panels.

The second design incorporates three solar panels positioned in a horizontal pattern (Figure 45). The frame is made from 3mm hot dip galvanized steel. Galvanizing is when a thin layer of molten zinc is dispersed across the steel “to form a source of corrosion protection for steel” (Hot Dip Galvanzied Steel, What, How & Where 2011). The bolts are made from stainless steel because of its minimal rusting characteristics. The cross brace at the back is designed to provide extra support. The 30 degree inclination in the frame is applied to accommodate the suns angle of elevation. The mast and foundation are designed to be exactly the same as the indicator mast (Section 9.10.2), although, the larger weight from the solar panels will alter the foundation’s sizes which is determined by the structural company BG&E.



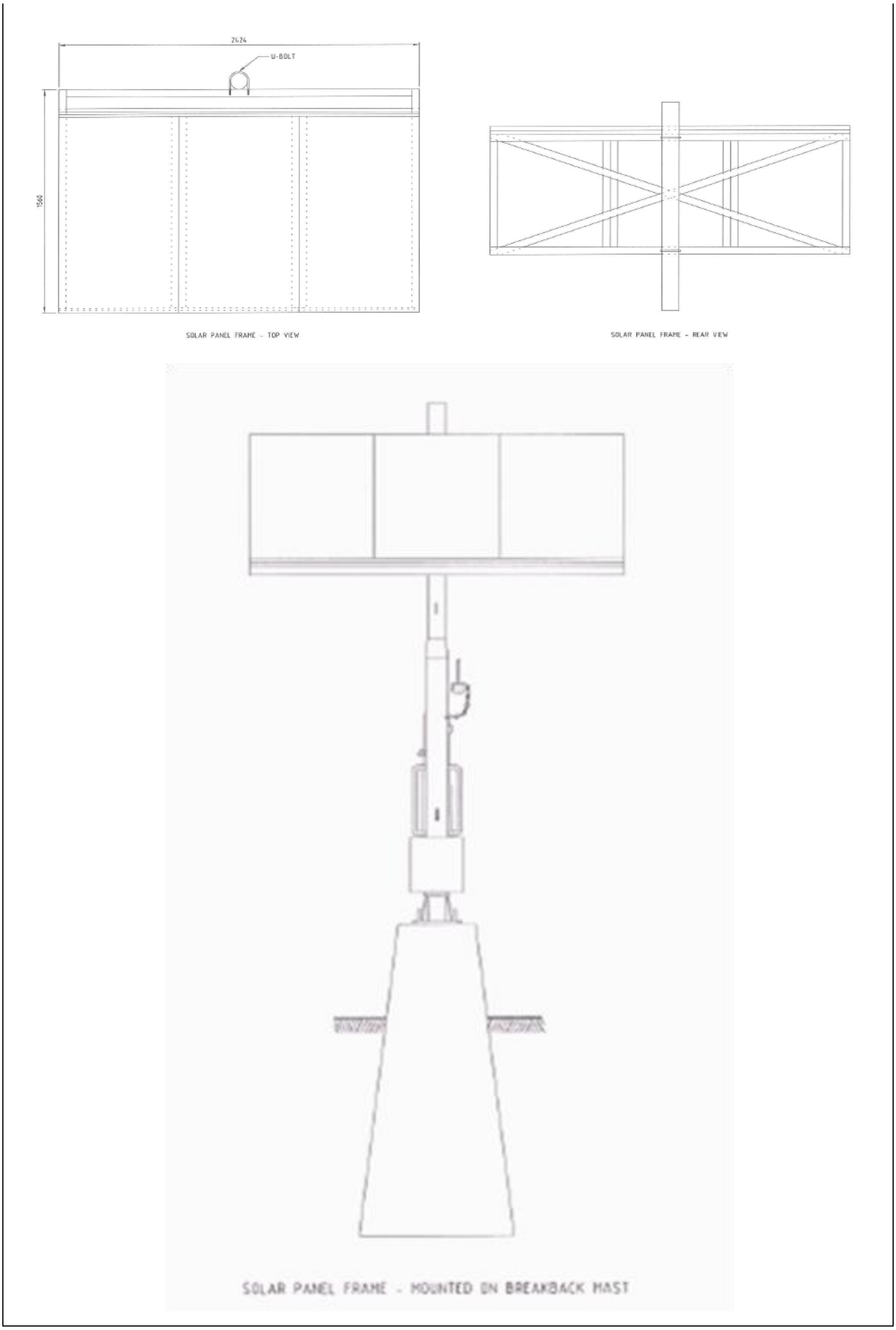


Figure 45: Break Back Solar Panel Design

Especially as the drafting expense was avoided, the cost of the masts and solar frame was not expensive. The response from the structural company states "due to the risk of such a large wind load, and it has to be mid hinge and therefore minimum 4 metres high. But it does unhinge to a very low level working height at that height and load it involves a very big footing at 900mm diameter, at worst case 2100mm deep, alternatively a slab of 2000mm x 200mm x 700mm deep plus centre cage assy." (G. Fish, 2012). Poor access for installation eliminates this design.

The ODG SA Construction Manager (Mike Green) designed a frame for the solar panels that is able to support the weight of the panels and has easy installation requirements. This design is displayed in Figure 46. The frames consists of four masts that are

- M10 Galvanised bolts with spring washers and flat washers for the frame.
- M6 stainless steel security screws with stainless steel flat washers and spring washers for solar panels.
- 80x40x1.6 galvanised dipped steel beams for the bracing
- Each mast requires a footing of 600mm x 600mm x 650mm deep

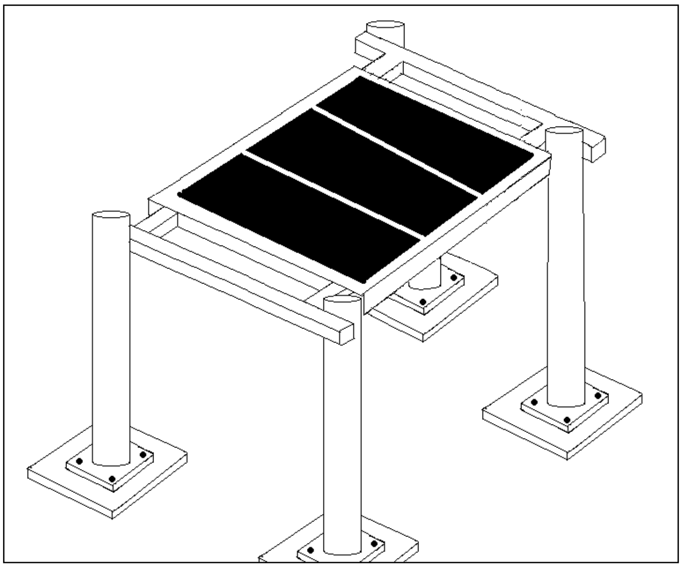


Figure 46: Solar Panel Frame

The structural company BG&E required the following modifications:

- 75 x 50 x 2.0 galvanised dipped steel beams for the bracing
- All steel to be galvanised dipped

- Site welds to be cleaned and coated with zinc-rich epoxy
- Weld the mast 30mm each side to unistrut

Now with this new design as shown in Figure 47, easy installation has compensated for easy maintenance.

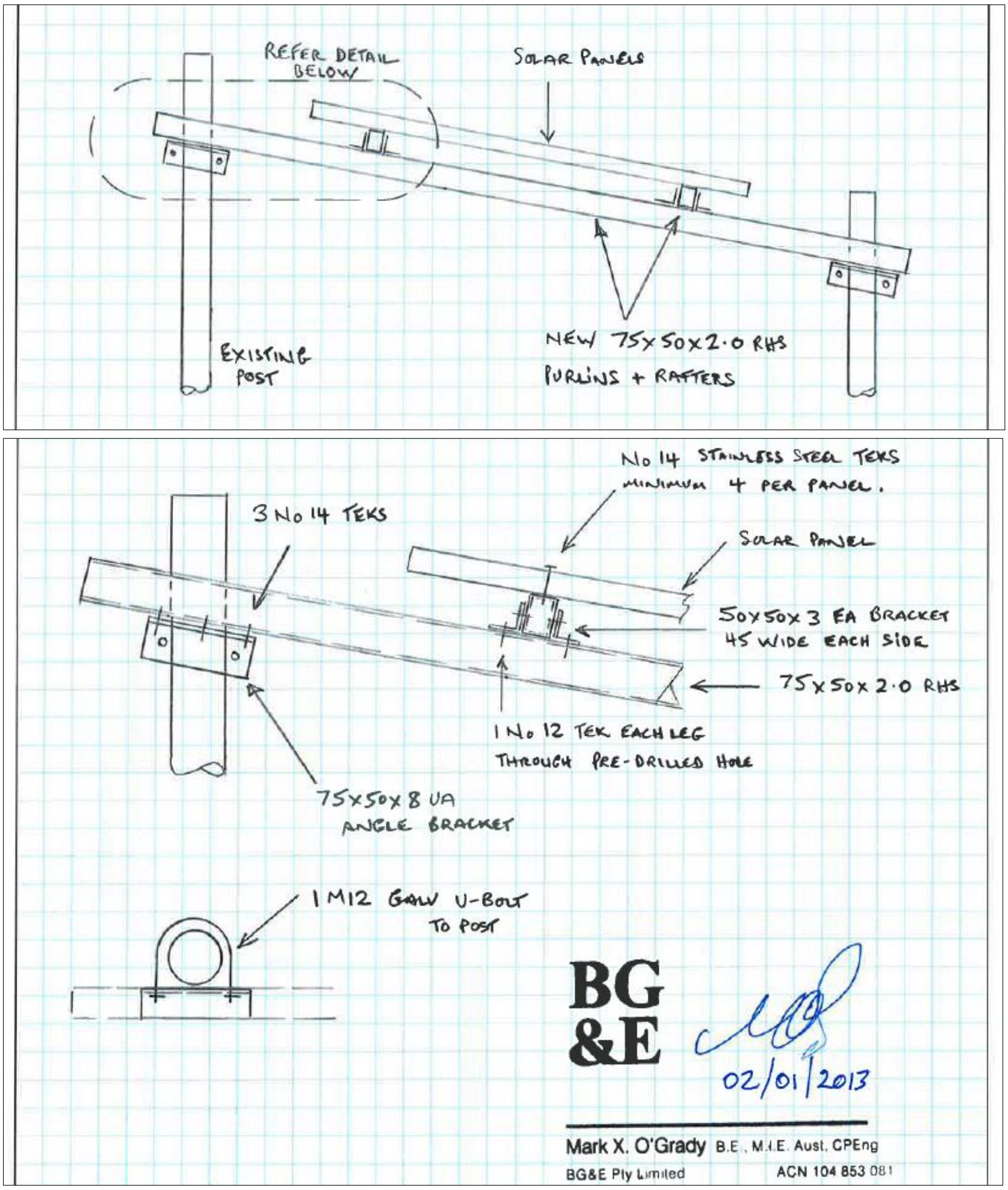


Figure 47: Solar Panel Frame Improvements

9.12 Earthing

The client provided a design for the earthworks. This design is shown in Figure 48.

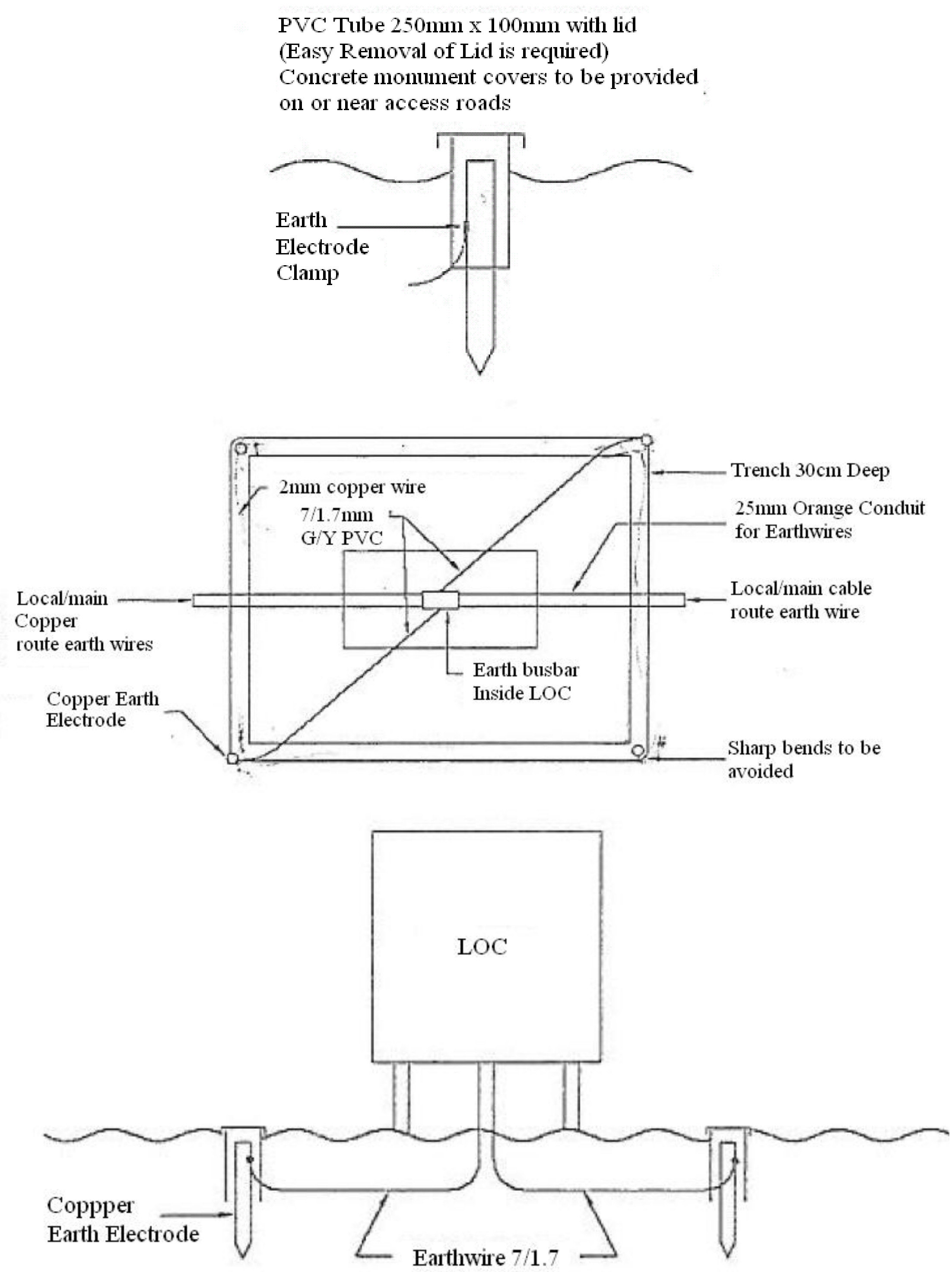


Figure 48: Earthing Design

The design incorporates the use of four (4) copper electrodes that are positioned in a rectangular shape around the LOC. Each electrode is connected to the Earth busbar that is located inside the LOC.

9.12.1 Earthing Design Discussion

"The electrical earthing system is designed to provide a safe and correct operation of the network under normal, earth fault, and transient conditions.

It should also be recognised that soil resistivity varies with the seasons. In wetter months the soil resistivity will be low and in drier months it will be higher. Adequate earthing should be installed to ensure the target resistances are achieved in the drier months" (Engineering 2012).

The sandy conditions make it difficult because "moisture tends to drain the sand' (Engineering 2012) so a good conducting material is required. The design that is provided from the client involves the use of copper rods. "Copper has a very high electrical and thermal conductivity...it has a high resistance to corrosion, forming an oxide on its surface" (D. G. Fink 1982) . These types of properties will benefit the earthing system. The high resistance to corrosion will be an added advantage since Darwin has a humid climate.

The rods are to be situated apart at least twice the length of the rods. The earth wire of 7/1.7 is an electrical standard. (Szacsvay 2012).

10 Procurement & Fabrication

As displayed in Figure 49, Procurement and Fabrication is the second phase within the project life cycle.

Figure 49: Procurement & Fabrication

These two departments work together to source materials and fabricate the clients' equipment not only on time but also to a clearly defined scope.

10.1 Procurement Overview

Procurement is the attainment of goods or services. The principle factor that procurement focuses on is the potential loss of labour. This occurs when staff is unable to construct/fabricate designs due to a delay of materials. It is costly and inefficient. To prevent these situations from occurring, procurement use suppliers that meet the following criteria:

- **Responsive people** – a delayed response in quotes may cause further delay in equipment delivery.
- **Lead time** – the lead time is important and may determine changes in the type of equipment on a time-restricted project.

- **Location** – the location of the supplier may add extra delay and cost, as freight may have to be included.
- **Reliability and delivering to date.** The reliability of a supplier is based on past experience from proven suppliers.

Not only is responsibility placed onto the suppliers but on also the fabrication team. Procurement must have reliability and confidence in fabrication to ensure the design can be built with the ordered equipment and the design meets client requirements.

My assistance in this stage of the lifecycle includes:

- Ensuring that all equipment is mounted in accordance to their specification sheet.
- Organising supplies
- Arranging a schedule and a completion deadline with the fabrication team

10.2 Fabrication Overview

Fabrication deals with not only constructing the equipment but must also consider many other aspects of the project. Fabrication must ensure that all equipment is built to a strict standard and that all parts and equipment meet the client's basic standards detailed in numerous standards. Client interface meetings are common to ensure construction milestones are met and that the project is tracking on time. The fabrication department must also consult various disciplines of the engineering department frequently to discuss solutions to various design problems. ODG fabricate as per the circuit designs and always construct the product to be as safe and user friendly as possible taking into account things such as ergonomics, future expansion and any site specific regulations. The main factors that fabrication encompasses are:

- **Logistics** -This includes planning the process of fabrication by obtaining lead times, client's requirements and point of destination.
- **Designing** – fabrication may lead design especially for the layout of LOCs. Not only to meet the clients requirements and functionality of the system but to make the quality of the LOC attractive to potential buyers.
- **Mounting specifications of equipment** - including spacing and positioning
- **Wiring specifications** – this includes type of wire, width and insulation

- **Cable looming** includes ducting, to make sure the power and signal cables are assembled to Australian Standards.
- **Labelling.** Labelling is an extension that ensures a user friendly product and accurate installation of equipment.
- **Electricians** are the only workers permitted by the client to carry out work on their projects. These electricians must be fully CERT III qualified and many have had years of experience on rail projects.

10.2.1 Fabrication Procedure

The LOCs are the only items that need to be fabricated and assembled. The following describes the method of fabrication for the SFD project:

- **Fixings -**include stainless steel bolts because they have the least corrosion characteristics which are ideal for a humid climate in the Northern Territory. All fixings use a spring washer and a flat washer. The spring washer is required because it locks when there is vibration to prevent any loosening during transportation.
- **Mounting** - unistrut is made from aluminium and allows easy construction. It is made as per the design and is sprayed with caliber paint to protect against corrosion. The Din rail and G rail are made from mild steel. They are designed to support the terminals, circuit breakers and TCA arrestors. Separation plates are inserted between the circuit breakers and relays to provide extras isolation. Bakerlight is a pre-made board that is used for mounting and to provide a clean finish. The Xantrex controller is raised to provide a 150mm clearance as specified in the specification sheet.
- **Earthing** - uses earth insulators to provide insulation. All earthing is run externally from the cable ducting. Cables are to be no less than 4mm in diameter.
- **Terminals -** Terminals are equally spaced for quality appearance. The positive terminals use a SAK3 terminal which provides a 2A fuse. The negative power terminal uses a SAK6N terminal; this is used for cables 6mm or less. Row C uses a SAK35N terminal.

- **Ducting**- the power and signal cables are not separated in this design as there was no need for segregation.
- **Lugs (compression-style crimp)** – it is required that 1-2mm of cable is showing out from the lugs, this to provide a visual assessment for the correct connection. A crimp register is also used to record the performance of the crimps for Quality control.

Figure 50 identifies the components that are utilised within the fabrication procedure.

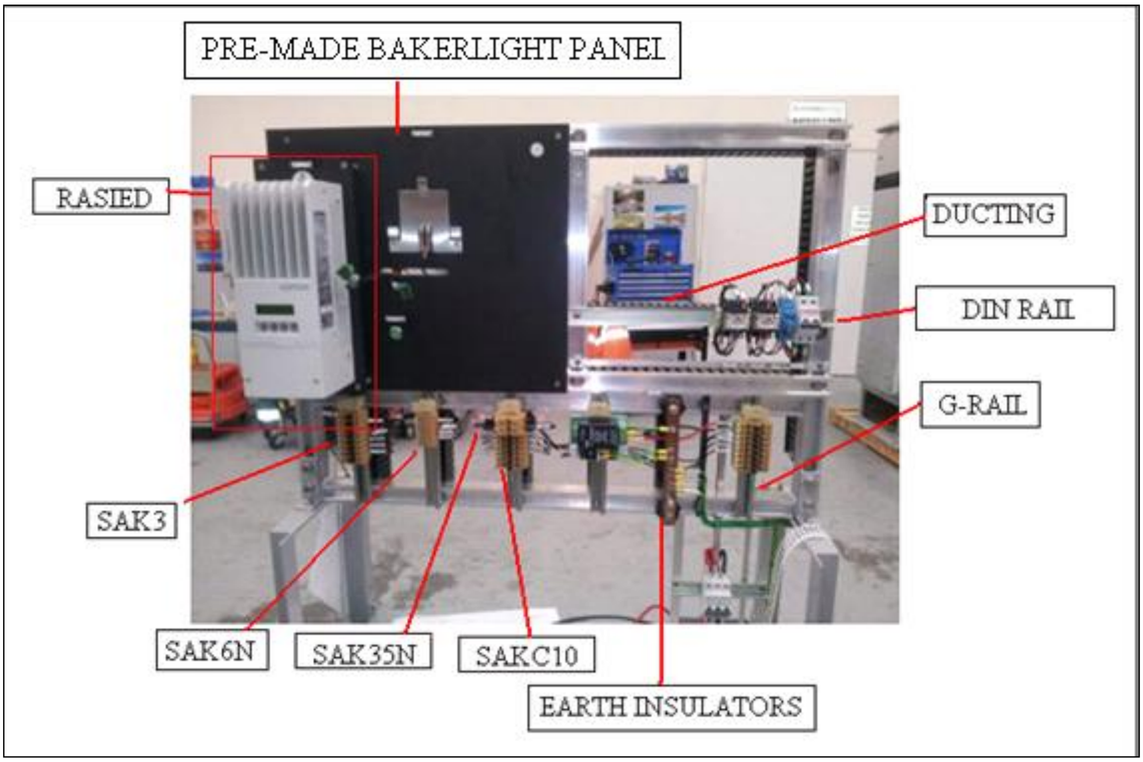


Figure 50: LOC Fabrication

The development of the LOC is displayed in Figure 51.

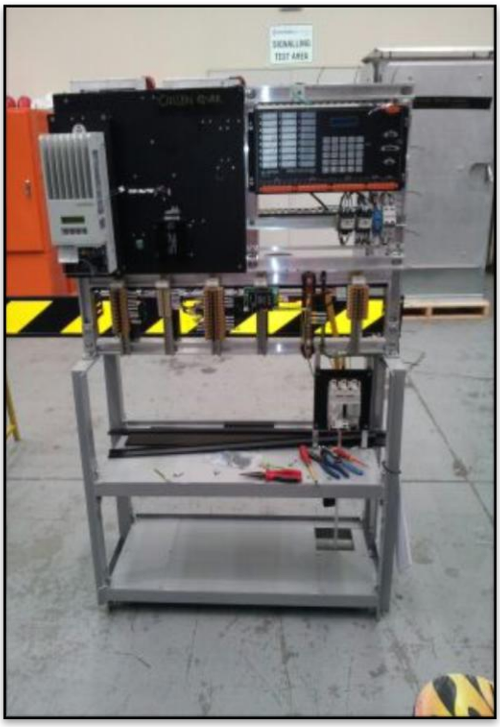
	
	

Figure 51: Fabrication LOC Development

11 Construction and Installation

The third phase of the project life cycle is construction and Installation (see Figure 52).

Figure 52: Construction & Installation

Construction and Installation involves preparing site for the installation of fabricated equipment, as well as building structures to fulfil requirements stated by the client. It composes of the outcomes of the previous two phases and upon completion allows visual, realistic outlook of the project.

My involvement with Construction and Installation incorporated:

- Participation in a site inspection
- Assisting the site manager with issues/problems that can be resolved in office, including ordering extra materials and supplying the LOC dimensions.
- Organising construction schedules with hire companies, mostly for the use of trucks and excavators.

11.1 Site Inspection

A site inspection was conducted 24^{th} – 26^{th} September 2012 with Project Manager (Asa Brown), Project Manager Assistant (John Ma) and the student (Charlotte Moss) in order to observe the progress of the project and provide a solution to any issues that may have arose. During the site inspection the following observations were recorded:

- Equipment used at existing huts. This can be used as a reference for ODG Designs.
- The type of masts and foundations utilised at existing locations along the GWA Rail line. As mentioned earlier, access to some of the sites is difficult; therefore it is beneficial to see what has been previously constructed. Figure 53 is an image of one (1) of the SFD's that were installed previous to the site inspection.

Figure 53: SFD Installation (image taken on 25/09/12)

Any questions/issues from Construction Manager (Mike Green) were noted also. For example, the type and size of the LOC is required to commence the installation on their foundations.

11.2 Structural Works

An overview of the structural works is provided in the following sections.

11.2.1 Clients Requirements

All foundations are supplied and installed to a minimum rating of the cyclonic Region 'C'.

Radio antennas to be installed on six metre break back mast

Indicators are to be installed 2.5km from the river.

11.2.2 Installation Strategy

Figure 54 shows the simple process of installing the equipment on site. Firstly, an excavator is used to remove the ground. Next, the ground is prepared with a sub base and conduit for cable access. Then, the ground is required to be compacted and levelled. Lastly, install the precast slab. The main approach is to commence building from the bottom of the structure and work upwards. The complete structural works on an indicator site is displayed in Figure 55.

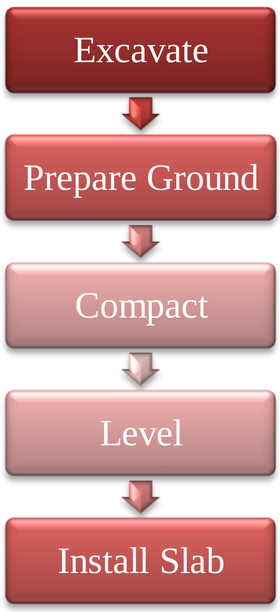


Figure 54: Structural Works Process

Figure 55: Cullen River Indicator Site (2013)

11.2.3 Observations & Recommendations

11.2.3.1 Indicators

The indicators are not exactly 2.5 km from the SFD site (as requested by the client). I recommend installing the indicators as close to this mark as possible not only to please the client but to reduce the occurrence of some issues. This includes the concern that the variety in distances affects the warning; it may provide extra time where the train may have passed the indicator and hence, may not receive the warning. On the other hand, train control will provide communication to inform the train driver.

Figure 56: Indicator Mast

Nevertheless, if the indicator is less than the 2.5km mark, it may not provide the required amount of stopping distance, in addition to a decrease in track length caused by possible flooding of the track. To ensure most reliability within the client's requirements it would be most effective to meet the 2.5km mark.

11.2.3.2 Radio Masts

Radio masts are to be break back and Katherine antenna is required to have a mast of 10 metres as determined from the radio survey. However, the mast installed at Katherine SFD site is 6 meters; this may affect the RF signal.

11.2.3.3 Solar Panels

Fergusson River Solar panel mast is built close to a tree which may cause shading over the solar panels as shown in Figure 57.

Figure 57: Fergusson River SFD Site

I would suggest removing the tree or relocating the mast.

11.2.4 LOC

The positioning of the SFD at each site was agreed by the Client and the Construction Manager. There is no requirement of how high the LOC needs to be above the SFD. This has resulted in Katherine being 50mm higher than the SFD as displayed in Figure 58.

Figure 58: Katherine River SFD Site

To provide protection to the equipment from the effect of flooding, the LOC can be raised using sand like in Cullen River (Figure 59).

Figure 59: Cullen River Indicator Site before completion

This solution will increase cost but will add 800mm height difference to the SFD. This can also been implemented at Ferguson River.

12 Testing & Commissioning

Testing and Commissioning is the fourth phase of the project life cycle as demonstrated in Figure 60.

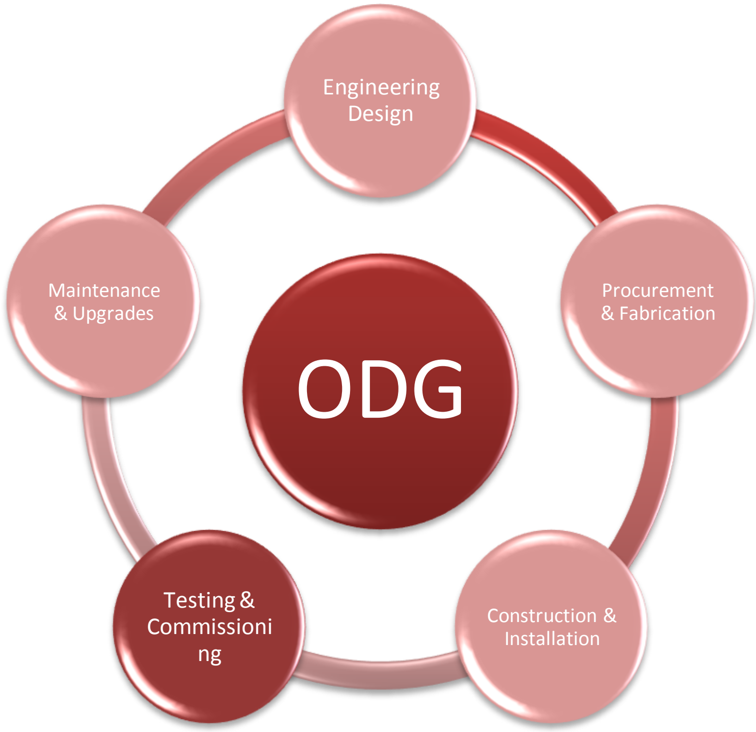


Figure 60: Testing & Commissioning

The Testing & Commissioning is the final evaluation of the clients' requirements. This part of the process corrects any faults and verifies that the product is working effectively and safely. It is comprised of two segments: factory acceptance testing (FAT) and site acceptance testing (SAT).

FAT allows the design to be tested in the factory; it allows any faults to be easily fixed as staff and supplies are readily available. It also certifies that the equipment transported to site is in working order which minimises any delay of correcting faults on site.

SAT requires staff to be mobilised and materials to be transported, it verifies that the equipment is working correctly after transportation and under site conditions. It is to be witnessed by a Client representative.

12.1 Clients Requirements

Upon completion of each SFD site installations, SAT shall consist of:

- SFD operational test and Systems Integration tests
- Sign-off each individual SFD site acceptance checklist by the Contractor and Company Representative.

12.2 Documentation

The sections below detail the documentation that is to be undertaken during testing.

12.2.1 Commissioning Briefing & Attendance Register

The Commissioning Briefing & Attendance Register (Figure 61) provides the documentation for the time of commencement and completion of the daily work performed on site and the persons present throughout that time. This sheet is to be completed at each site.

O'DONNELL GRIFFIN RAIL — 13-06-02 Commissioning Briefing & Attendance Register

Contract No.	NRG-GXA-LX	Briefing & Attendance Register	
Location	FERGUSSON RIVER	Master Test Certificate No.	GWA/MTC07/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming		Sheet 1 of 1

Start Time	Finish Time	Name	Signature
0810	1200	J Cole	
0810	1200	C. [illegible]	
0810	1200	C. MOSS	
0810	1200	B NICOL	
08/10	1200	J Ma	
0810	1200	M McCall	
0810	1200	A. LOCKHORST	
0817	1200	R McBrick	
0810	1200	M McCall	

Figure 61: Commissioning Briefing & Attendance Register

12.2.2 Commissioning Occurrence Log

Commissioning Occurrence Log (Figure 62) provides the documentation of the events that took place on site on a daily place. This is generally used as evidence when delays occur and extra time on site is required to complete the necessary tasks.

O'DONNELL RAIL — 13-06-03 Commissioning Occurrence Log

Contract No.	NRG-GWA-LX	Occurrence Log	
Location	ADELAIDE RIVER	Master Test Certificate No.	GWA/MTC04/001
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming	Sheet 1 of 1	

	Start Time	Finish Time	Description
6-12-12	1200	1215	Get to site & set up
	1215	–	Brief team
	1230	1245	Test SFD Cable
	1245	1300	Function SFD
	1300	1330	Test batteries
	1330	1400	Set up SEAR
	1400	1415	Set up Modmax
	1415	1425	Function SFD & Power alarm
	1425	1430	Pack up Site
8-12-12	830	0845	Set up & brief team
	0845	0915	Bell & Wire count Solar Panels
	0915	0935	Set up Xantrex
	0935	1020	Function Power
	1020	1030	Pack up Site

Figure 62: Commissioning Occurrence Log

12.2.3 Test Certificates

The Test Certificates contain the readings taken during SAT. Test certificates include:

- Master Test Certificate
- Site Location Test Certificate
- Signals Test Certificate
- Master Cable Certificate
- Cable Insulation Test Certificate

- Solar Array Test Certificate
- Location Earth Test Certificate

12.2.4 Test Log Index

Test Log Index provides the records of the test logs raised. The test logs are raised when changes/corrections need to be actioned to meet the client's requirements. Test logs are handed to the relevant personnel that will carry out the changes.

12.2.5 Test Equipment Register

The Test Equipment Register is a record of the equipment used during testing, detailing in the serial number and calibration date. It allows sites to be traced and re-tested, if a fault is discovered in the equipment.

12.2.6 Test Strap Register

The Test Strap Register is a record of the straps used during testing. Again, it also allows sites to be traced and re-tested, if a fault is discovered in the strap.

12.2.7 Test Copies

Test Copies are the copies of the design that are utilised during FAT and SAT. It records required changes and the verification of function testing. Appendix H contains the Test Copies for Ferguson River.

12.3 Testing Procedure

The Figure 63 details the tasks that are undertaken during testing.

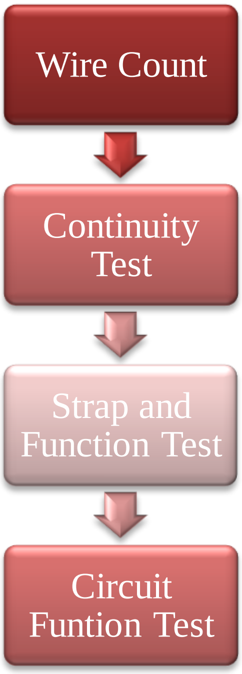


Figure 63: Testing Procedure

12.3.1 Wire count

Wire count is defined as a “visual examination to ensure that the correct number of wires/cables cores is securely connected to each terminating point as per the design and that the wires/cable cores are correctly labelled.” (Wire Count and Continuity Testing 2002). For accurate conduction of the wire count, the following is also required to be checked:

- Type of termination
- Size and type of wire
- The number of wires
- labelling

12.3.2 Continuity Test

Continuity Test is defined as “a test to ensure the continuity and correspondence of each individual wire. The wiring is tested using a bell tester set to ensure that the wiring has been run between the two points.” (Wire Count and Continuity Testing 2002) .Wire counting and continuity testing are carried out to ensure the following:

- The installation has been correctly wired according to the design.
- There are no additional wires terminated with those wires
- There are no wires terminated where there should be none
- Conductor resistance is acceptable
- The wiring has been run between the terminations specified

Wire count and continuity tests should detect all installation faults (if present) and some design faults.

12.3.3 Strap and Function Testing

Strap and Function Testing is defined as ‘a circuit function test where the presence and operation of each individual contact is verified by the operation of a test strap’ (Strap and Function Testing 2002).The Strap and Function test ensures that all the necessary contacts are wired into the circuitry. This is achieved by the following steps:

- Power up the circuit and connect a voltmeter to the end function
- Breaking the first contact in the circuit and ensure the voltage is lost on the meter and the end function does not operate
- Connect the strap across the open contact, check the voltage returns and that the end functions operates.
- Disconnect the strap and ensure that the voltage is lost and the relay, lamp etc. ceases to operate. (Mod 5 P10-Strap and Function Testing).

This process is repeated for every contact and link within the design.

12.3.4 Circuit Function Test

Circuit Function Test is defined as ‘a test of each individual circuit to verify the presence of the necessary controls, and prove that it works as designed’ (Cable Testing 2002). This test involves proving that the ends function, relay, lamp, etc. will operate by all various paths within the circuitry. All paths must be used in turn to prove that they will all operate the end function depending on the required conditions being present.

12.4 Outcomes

The outcomes from Testing are described below:

- Solar panel disconnection boxes are not installed. This is most effective when the solar panels are a fair distance away from the equipment. However, the solar panels are situated directly above the LOC and as a result do not require the disconnection box.
- Miri Telemetry earthing is removed. This is because a DC/DC Converter is located inside the unit, in which, the unit provides its own isolation.
- Communication between sites at Katherine River could not be established. This was a result from the 6 meter mast that was installed; results from the survey suggest that a 10 meter mast is to be installed. This will now be implemented at that site.

12.4.1 Lamp Voltages

The lamp voltages are recorded in Table 19.

Table 19: Lamp Voltages

Site	Green (V)	Yellow (V)
Edith River Northern Indicator Site	13.63	13.6
Edith River Southern Indicator Site	13.6	13.55
Ferguson River Northern Indicator Site	13.4	12.7
Ferguson River Southern Indicator Site	13.26	13.51
Cullen River Northern Indicator Site	13.57	13.18
Cullen River Southern Indicator Site	13.1	13.1
Katherine River Northern Indicator Site	13.30	13.63
Katherine River Southern Indicator Site	13.43	13.23
Adelaide River Northern Indicator Site	13.32	13.63
Adelaide River Southern Indicator Site	13.72	13.70
Elizabeth River Northern Indicator Site	13.25	13.28
Elizabeth River Southern Indicator Site	13.60	13.54

Voltage readings from the lamp are taken to ensure the indicators are fully working. Table 25 shows that there are no unusual readings and that the indicators at all sites are working correctly. The readings are recorded on the Signals Test Certificates.

12.4.2 Earthing Results

Table 20 displays the earthing results. The Earth resistance values are required to be less than 5Ω as requested by the client. The sandy areas at the site locations make it difficult for a good earthing system. Table 26 displays some unacceptable readings at sites. To overcome this problem, the earthing pad shall be extended, also, extra rods shall be installed improve the earth resistance readings.

Table 20: Earthing Results

Site	Resistance (Ω)
Edith River Site	6
Edith River Northern Indicator Site	6.5
Edith River Southern Indicator Site	6.5
Ferguson River Site	6
Ferguson River Northern Indicator Site	7.8
Ferguson River Southern Indicator Site	7.3
Cullen River Site	18
Cullen River Northern Indicator Site	5
Cullen River Southern Indicator Site	12
Katherine River Site	5
Katherine River Northern Indicator Site	4.75
Katherine River Southern Indicator Site	11
Adelaide River Site	8
Adelaide River Northern Indicator Site	7
Adelaide Southern Indicator Site	7
Elizabeth River Site	4.6
Elizabeth River Northern Indicator Site	4.8
Elizabeth River Southern Indicator Site	4.9

12.4.3 Busbar Readings

Busbar Readings are taken to ensure the correct voltage is applied to the system. This is a 12V system and hence the readings taken in Table 21 are acceptable. The busbar readings are recorded in the Site Location Test Certificate.

Table 21: Busbar Readings

Site	12V	+ve Earth	-ve Earth
Edith River Site	13.8	0	0
Edith River Northern Indicator Site	13.8	0	0
Edith River Southern Indicator Site	13.4	0	0
Ferguson River Site	12.5	0	0
Ferguson River Northern Indicator Site	12.6	0	0
Ferguson River Southern Indicator Site	12.75	0	0
Cullen River Site	13.4	0	0
Cullen River Northern Indicator Site	13.13	0	0
Cullen River Southern Indicator Site	13.5	0	0
Katherine River Site	13.8	0	0
Katherine River Northern Indicator Site	13.2	0	0
Katherine River Southern Indicator Site	13.68	0	0
Adelaide River Site	13.05	0	0
Adelaide River Northern Indicator Site	12.8	0	0
Adelaide Southern Indicator Site	12.5	0	0
Elizabeth River Site	13.4	0	0
Elizabeth River Northern Indicator Site	12.5	0	0
Elizabeth River Southern Indicator Site	13.14	0	0

12.4.4 Cable Insulation Readings

Table 22 displays the averages of the readings taken on the 4 core cable that is utilised at each site. Minimum insulation readings are to be greater than 200 Mega ohms for new cables. All sites satisfy this.

Table 22: Cable Insulation Readings

Site	Cont.	C-C	C-E
	Loop Ω	MΩ	MΩ
Edith River Site	0.2	>200	>200
Edith River Northern Indicator Site	0.2	>200	>200
Edith River Southern Indicator Site	0.1	>200	>200
Ferguson River Site	0.5	>200	>200
Ferguson River Northern Indicator Site	0.2	>200	>200
Ferguson River Southern Indicator Site	0.2	>200	>200
Cullen River Site	0.6	>200	>200
Cullen River Northern Indicator Site	0.6	>200	>200
Cullen River Southern Indicator Site	1	>200	>200
Katherine River Site	0.5	>200	>200
Katherine River Northern Indicator Site	0.6	>200	>200
Katherine River Southern Indicator Site	1.1	>200	>200
Adelaide River Site	0.8	>200	>200
Adelaide River Northern Indicator Site	0.8	>200	>200
Adelaide River Southern Indicator Site	1.2	>200	>200
Elizabeth River Site	0.4	>200	>200
Elizabeth River Northern Indicator Site	0.5	>200	>200
Elizabeth River Southern Indicator Site	0.5	>200	>200

12.4.5 Solar Array Readings

The Short circuit current readings and the open circuit voltage readings are required on the solar panels; this is to ensure that solar panels are supplying power. The readings displayed in Table 23 are the averages of all three solar panels. The variation in current and voltage at each site is dependent on the current weather conditions when testing. There are no unusual readings which prove that the solar panels are fully functioning at all sites. The readings are recorded on the Solar Array Test Certificate.

Table 23: Averages of Solar Array Readings

Site	Watts	OC Voltage (V)	SC Current (A)
Edith River Site	195	39.75	6.04
Edith River Northern Indicator Site	195	39.75	6.05
Edith River Southern Indicator Site	195	37.01	7.002
Ferguson River Site	195	37.82	6.01
Ferguson River Northern Indicator Site	195	38	4.5
Ferguson River Southern Indicator Site	195	38.21	4.3
Cullen River Site	195	37.91	4.8
Cullen River Northern Indicator Site	195	40.83	2.10
Cullen River Southern Indicator Site	195	41.91	3.03
Katherine River Site	195	39.21	4.8
Katherine River Northern Indicator Site	195	41.03	4.91
Katherine River Southern Indicator Site	195	39.15	5.21
Adelaide River Site	195	40.82	2.09
Adelaide River Northern Indicator Site	195	40.66	1.74
Adelaide River Southern Indicator Site	195	41.13	5.53
Elizabeth River Site	195	38.25	4.3
Elizabeth River Northern Indicator Site	195	37.93	4.8
Elizabeth River Southern Indicator Site	195	40.83	2.10

12.5 Commissioning

SFD Commissioning was completed on 6th December 2012 for all SFD sites. Figures 64 & 65 display the alarm received by the client during testing at Adelaide River.

```
Subject: WAMS ALARM - Adelaide River SFD - ALARM -SFD#1 Stream Flow High

Location Type:     CROSSING
Location Name:     Adelaide River SFD
Milepost:          2649.748KM
DOT Number:        2649
Recorder Type:     SEARII
Auto Tester:       No
ATCS Address:      7.048.110.032.99.01

Field Recorded:    12/06/2012 2:26:34 PM
Alarm Description: ALARM -SFD#1 Stream Flow High

Trouble Ticket:    NONE

To retrieve event log information for this location now, click here:
http://LocalHost/WebWams/WebWams.asp?WCI=eventlog&WCE=481100329901E


To view an alarm report for this location now, click here:
http://LocalHost/WebWams/WebWams.asp?WCI=location_alarms&WCE=481100329901E
```

Figure 64: SFD High Alarm

```
Subject: WAMS ALARM - Adelaide River SFD - MESSAGE - SFD#1 Stream Flow Normal

Location Type:     CROSSING
Location Name:     Adelaide River SFD
Milepost:          2649.748KM
DOT Number:        2649
Recorder Type:     SEARII
Auto Tester:       No
ATCS Address:      7.048.110.032.99.01

Field Recorded:    12/06/2012 2:27:24 PM
Alarm Description: MESSAGE - SFD#1 Stream Flow Normal

Trouble Ticket:    NONE

To retrieve event log information for this location now, click here:
http://LocalHost/WebWams/WebWams.asp?WCI=eventlog&WCE=481100329901E


To view an alarm report for this location now, click here:
http://LocalHost/WebWams/WebWams.asp?WCI=location_alarms&WCE=481100329901E
```

Figure 65: SFD Low Alarm

The Indicator sites were commissioned throughout January 2013.

13 Maintenance & Upgrades

Maintenance and Upgrades is the final phase of the project life cycle (Figure 66).

Figure 66: Maintenance & Upgrades

13.1 Maintenance

13.1.1 Client Requirements

The contractor shall supply site specific operation and maintenance manuals for each new location. Maintenance folders shall be of sufficient detail to allow the Company Representative to fully test, repair and otherwise maintain the equipment.

13.1.2 Maintenance

GWA will be maintaining all sites. A copy of the completed design is left at each location.

MDRs are also provided for the client. MDR's will be compiled in accordance with client and contractual specifications and standards. The Quality department is responsible for the compilation and verification of the MDR's. Client requirements may specify that originals of the following documents are preferred for inclusion into the physical MDR folder:

- Test & Commissioning records
- Overall Certificate of Compliance
- Contractor Signatory List
- Inspection & Test Plans and referenced verifying documents

The spare equipment requested by GWA is provided in Table 24.

Table 24: Spare List

GWA SFD Spare Materials List			
Description of item	**Manufacturer/ Supplier**	**Part No**	**Qty**
Miri Modem	Miri Technologies	AD2006	2
Lightning protector	Miri Technologies	LA-NFF	2
Omni Directional antenna(side mount)	Miri Technologies	SMD4-1	2
12V Omron relay (DC relay)	Omron	LY4N	2
Relay finder 40.51S	Finder	40.51.7.12.0000	2
Relay finder 40.52S	Finder	40.52.7.12.0000	2
Terminals SAKC 10	Weidmuller		10
Terminals SAK 35N	Weidmuller		10
Fuse terminals SAK6N	Weidmuller		10
Fuse terminals SAKS1 5A	Weidmuller		10
Fuse terminals SAKS5 2A	Weidmuller		10
Solar Panels 24V, 195W	Suntech	STP195S/24	5
Solar Controller	Xantrex	XW-MPPT60-150	2
Surge arrestor	TCA	TC-150/802WE	2
Surge arrestor	TCA	TC-18CS/S4	2
Batteries	Sonnenschein	NGSB060330HSOCA	5
3G Modem (InteliMax)	Maxon	MA-2015	2
Power/serial Cable (InteliMax)	Maxon	CAB-RJ45-DB9	2
Antenna Surge Arrestor	Maxon	MA-8010	2
DC-DC converter 12-12, 3A	Mascot /Farnell	8862	2
Circuit Breakers	ABB	S202/C10	2
Circuit Breakers	Schnetser electric	c60N, 63Amps	2
Circuit Breakers	Terasaki	S160-NJ-3-160	2

13.2 Upgrades

Upgrades can be easily added as the system already includes an extra 10% load capacity for future expansion.

A recommended upgrade would be to use the low voltage alarm in the Miri telemetry radio. This alarm has already been pre-programmed in the unit. However, extra circuitry and extra programming on the SEAR II would need to be performed. Yet the outcome is beneficial as the client will be informed if the radio links do not receive enough voltage.

Another upgrade is to provide the Miri radio antennas on a 6 meter break back mast, this will allow for easy maintenance.

13.3 Improvements/Alterations

The improvements/alterations that are detailed below acknowledge that the client determined their requirements at the initiation of the project; they focus on the main aim of the SFD project, which is to deliver an asset protection system in order to reduce the risk of derailment caused by flooding.

A possible improvement of the project could be to place the SFD directly under the centre bridge. This will provide a more accurate warning because it can detect the water level exactly at the bridge rather than inland. Extra cost is required for the support of the SFD underneath to bridge but I trust that a more accurate and quick detection may compensate for the installation costs. The NT Government utilises this arrangement to monitor weather conditions.

Another consideration could be to include two SFDs similar to the FMG design. The SFD positioned closer to the track can provide a red aspect to inform the train drivers to stop. Although involving a red aspect will require extra indicators, which will increase expenses in design, materials and labour. It will also provide an official stop warning rather than proceed with caution as the track could possibly be obstructed.

To improve the above suggestions further, the combination of both designs will provide an effective warning system. This includes two SFDs supported at two separate heights under the bridge.

The Client could also decide to install track circuits. Track circuits are used to detect the absence of the train; the SFDs can interface with the track circuit and essentially cut the track circuit when the SFD becomes de-energised. This method is used in FMG and BHP railway systems. Track circuits are very accurate and are useful for monitoring busy rail lines. A disadvantage is that it would be extremely expensive and time consuming to install a track circuit from Adelaide to Darwin.

Other water level detection systems include:

- Pressure transducers
- Shaft encoders
- Bubblers
- Ultrasonic distance sensors (similar operation to the police speed radars)

Instead of focusing on water level detection to suggest that the track may be obstructed, another proposal is to directly focus on the bridge itself. This type of detection can not only identify bridge washaway caused by flooding but can also recognise any affect that may cause the bridge to collapse. This may include other severe weather conditions such as cyclones or even collisions from a plane or truck.

Methods for monitoring the bridge include:

- 3D Laser scanning
- Accelerometers
- Automated Laser Total Station
- Fiber optics

14 Health, Safety and Environment (HSE) Considerations

Safety is paramount. Safe working practices were secured whilst participating in the Internship; all workers ensured that all processes and tasks that are executed throughout the project are in accordance to the company's safety requirements.

ODG Haden provide all of its employees and its subcontractor employees appropriate personal protective equipment, appropriate training in the utilisation of the equipment and safety information. To explore this further, the content below investigates hazards and the appropriate risk management tools. (ODG RAIL-Project Management Plan n.d.)

14.1 Hazards

ODG Haden make sure hazard controls are applied during each phase of the lifecycle. Examples of these hazards are:

- Working within 3m of the railroad
- Crossing of rail tracks
- Working on or next to road traffic
- Working in confined spaces
- Electrical works
- Working at heights.

Similarly, hazards resulting in a person's workplace may affect the safety of those who follow. The means of controlling each particular risk are identified in the Risk Management Tools. If a risk is discovered and does not appear to be substantially controlled, the supervisor should be consulted. Personal safe practise is a necessity.

14.2 Risk Management Tools

To guarantee the most safe and efficient product/workplace, ODG Haden comply with the polices listed below:

- Quality Assurance Policy
- Occupational Health & Safety Policy
- Environmental Policy
- Rehabilitation Policy
- Harassment and discrimination Policy

- Drug & Alcohol Policy
- Sustainability Policy
- Equal Opportunity Policy
- Fit for Work Policy

The subsections below explain a broad overview of the main Risk Management Tools utilized within the company.

14.2.1 Job Hazard Analysis (JHA)

A Job Hazard Analysis is to be completed before the execution of work. Key activities include:

- Identification of risks to the project
- Risk analysis
- Determine risk exposure
- Identify risk treatment and incorporate into the schedule and budget
- Ensure all risks and risk treatments are documented

14.2.2 Training

Workers need to complete internal, site and employer inductions. It is important that all workers are fully competent to carry out the task at hand. Other training such as the 4-wheel driving courses and radio coverage courses are provided for relevant personnel. The certificate for completion of the GWA Track Awareness course is locating in Appendix C.

14.2.3 Electrical Safety

Electrical shock is a possibility when working with electrical equipment and can range from a minor injury to death. Persons working in the electrical field need to possess the appropriate qualifications. The SP–E-01 Electrical Safety Procedure confirms that "all electrical equipment unless proven otherwise is to be treated as live." The rules and regulations within the Electrical Safety procedure must be followed at ALL times.

14.2.4 Fitness for Work

The persons involved in the project must be fit and competent (by training or experience) to undertake the work given. The term 'fit' relates to:

- Medically
- Not fatigued
- Not under the influence of drugs or alcohol
- In a state that does not prevent a person from working safely

ODG Haden provides a "Fitness for Work" program that facilitates such requirements. (HSE Manual 1.3 ODG Fit for work Policy n.d.)

14.2.5 Personal Protective Equipment (PPE)

All PPE confirm ODG Haden standards and follows the SP-PP03 Personal Protective equipment procedure. PPE is to be provided when particular hazards pose a risk to safety. All personnel are supplied with the appropriate eye protection, foot protection, head protection, hearing protection, high visibility clothing and safety harnesses. All PPE must be worn clean, correctly and in good condition.

14.2.6 Manual Handling

The SP –M-01 Manual Handling Procedure requires measures to be taken to reduce the risk of injury from handling loads. A basic level of knowledge on manual handling is expected, however, the supervisor will advise on further precautions to take for higher risk operations. Generally, stand close to the load, bend the knees, lift with the legs and avoid twisting movement. (SP-M-01 Manual Handling Procedure n.d.)

14.2.7 Vehicles

To secure premium safety with the use of site vehicles, they must pass the Fatal Risk Control Standard. All vehicles need to be fully equip for every situation, including, the harsh weather conditions that can incur on site. If any incidents do occur, extreme isolation from major towns/cities poses a greater risk.

14.2.8 First Aid

A list of first aiders is notified in the crib rooms and offices. First aid kits, fire fighting equipment and eye wash stations are located around the offices and in site vehicles. (AS/NZS 4801:2001 Occupational Safety and Health Management n.d.)

14.2.9 Environmental Management Plan

ODG Haden follows an Environmental Management Plan to ensure minimum impact on the environment. The environmental Management Plan includes:

- Controlled waste
- Protection of Flora and Fauna
- Solid Waste and Recycling
- Environmental Compliance checklist
- Site clean up (ODG-PLN-002 WA Environmental Management Plan n.d.)

14.2.10 Controlled Waste

Controlled waste relates to the proper disposal of any item that may harm the environment, such as solvents, tyres, batteries etc. The means of control are:

- To store waste in designated areas
- Ensure emergency procedures
- Ensure waste disposal have the appropriate licences and permits.
- Assess alternate management strategies. (ODG-EP-002 Controlled Waste n.d.)

14.2.11 Flora and Fauna

The ODG-EP-007 Flora and Fauna procedure pays particular attention to potential harm on the environment. Destruction or harm to flora and/or fauna will impact upon the ecological balance, in turn; this will affect the environmental health of the area. (ODG-EP-007 Flora and Fauna n.d.)

14.2.12 Site Clean up

It is compulsory that all foreign material is to be removed from the site location and left tidy after every shift. There is a site inspection before the project is announced complete.

15 Standards and Guidelines

All work carried out conforms to Australian Standards and follows the ENG450 Internship guidelines. Australian Standards include but are not limited to [Australian Standards, 2012]:

- AS 1170 Minimum design loads on structures
- AS 1250 The use of steel in structures
- AS 1650 Hot-dipped galvanised coatings on ferrous articles
- AS 1664 Rules for the use of aluminium structures
- AS 1768 Lightening Protection
- AS 1882 Earth and bonding clamps
- AS 2005 Low voltage fuses – Fuses with enclosed fuse-links
- AS 2053 Non-metallic conduits and fittings
- AS 2915 Solar photovoltaic modules – Performance requirements
- AS 3000 Electrical installations – Buildings, structures and premises
- AS 3008 Electrical installations – Selection of Cables
- AS 3080 Telecommunications installations – generic cabling from commercial premises
- AS 4799 Installation of underground utility services and pipelines with railway boundaries
- AS/ACIF S008:2010 Requirements for authorised cabling products
- AS/ACIF S009:2006 Installation requirements for customer cabling (wiring rules)

16 Conclusion

16.1 Project Outcome

The main factors to be considered when evaluating the NT SFD project include:

- Reliability, availability and maintainability
- Defined functional requirements
- Standards and specifications

The project was proven to be safe working and verified by the client to be fully functional and entirely operational. In comparison to the initial SOW, the following were accomplished:

- New or modified asset protection location and associated equipment to monitor the SFD and provide sms alarms back to GWA personnel.
- New radio communication networks between sites
- 10 days of backup power supply at each site using solar arrays and battery capacity.
- All structures are designed to a minimum rating of cyclonic Region ‘C’.
- Indicators are located 2.5km from its associated river.
- Indicators are permanently illuminated using the preferred type of Westinghouse easy access signal mast.
- SFD tanks and switches are supplied and installed.
- All designs are in line with Australian Standard design and quality control processes and procedures.

Variations from the SOW are a result from poor accessibility to sites and materials with long lead times. Differences include:

- Although the solar panels are raised off the ground, they are not mounted on a break back mast.
- Original preferred 3G modems have been replaced to a later version of that modem due to internal software issues.

On another note, although a project behind schedule is not anticipated, it is extremely common in the engineering industry and unfortunately was the case for this particular project. The delay in materials caused a significant delay in commissioning; even though the completion of the entire project was behind schedule, communication between the river locations and train control was established and an alarm system was in operation before the wet season. The train drivers do not have a physical indicator on the track at the start of the wet season but they did have contact with train control, who is informed of any alarms that arise. The indicators sites were commissioned throughout January 2013.

Overall, on a technical scale the completion of the project has proven to be successful.

16.2 Internship Outcome

Throughout the course of the internship, I assumed the role of Project Engineer and participated in:

- Establishing the SOW
- Establishing, confirming and allocating the design requirements derived from client, contract and stakeholder specifications, including:
    - Indicator design
    - Solar panel design
    - LOC design
- Providing technical support to the Project Manager especially:
    - Power Calculations
    - Radio links
    - SEAR II configuration
    - Modem configuration
- Purchasing
- Customer liaison
- Coordinating, assisting and managing technical activities through the lifecycle of the project, including Procurement, Fabrication, and Testing & Commissioning.

I was able to apply information towards the project from units learnt at University. For the communication links the following units were very helpful:

- **ENG345 SCADA and Instrumentation Systems** – I was able to understand the operation of the communication links from topics that are covered throughout this unit.
- **ENG306 Real Time and Embedded Systems** – I was able to adapt to new programs easily because of the large variety of programming languages learnt in this unit.
- **ENG305 PLC Systems** - The Miri telemetry radio used PLC programming, therefore, I was able to understand the techniques that are implemented in the programme.

For the power supply and electrical design, the following units were helpful:

- **ENG348 Power Transmission and Distribution Networks** – This unit provided the knowledge that is required to perform the power calculations.
- **ENG349 Power Electronic and Converters and Systems** – This unit provides a good background in Converters. I was able to understand the functionality of the DC/DC converter that is used to provide clean power to the 3G Modem.

Overall, I was able to appreciate the amount of thought, effort and team work that goes into a project. There is a great sense of achievement from initially having a rough sketch on a piece of paper to seeing the design in real life. I was able to appreciate the course of actions that are necessary to guarantee that the equipment is working effectively.

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18 Company Documents

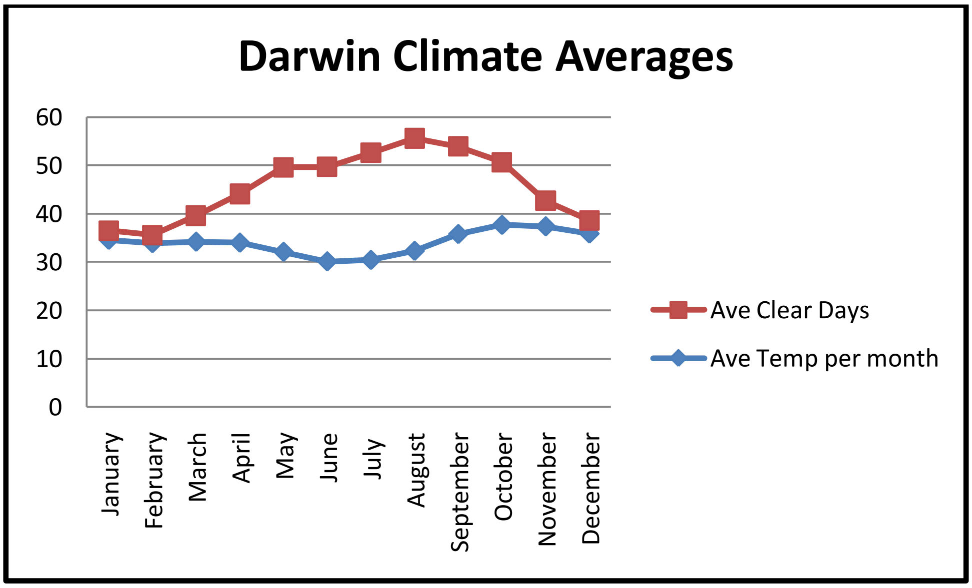
ODGRAIL-GWA-SOW-0001	SOW NORTHERN TERRITORY STREAM FLOW DETECTORS (SFD) DESIGN, SUPPLY, CONSTRUCT AND COMMISSION
Power Calculations	
ODGRAIL-GWA-CALC-0017	Power Calculations - Katherine River SFD 2448.1km
ODGRAIL-GWA-CALC-0018	Power Calculations - Katherine River Southern Indicator 2446.100km
ODGRAIL-GWA-CALC-0019	Power Calculations - Katherine River Northern Indicator 2450.645km
ODGRAIL-GWA-CALC-0020	Power Calculations - Edith River SFD 2490.8km
ODGRAIL-GWA-CALC-0021	Power Calculations - Edith River Southern Indicator 2488.224km
ODGRAIL-GWA-CALC-0022	Power Calculations - Edith River Northern Indicator 2493.272km
ODGRAIL-GWA-CALC-0023	Power Calculations - Fergusson River Backup Creek SFD 2504.224km
ODGRAIL-GWA-CALC-0024	Power Calculations - Fergusson River Backup Creek Southern Indicator 2501.693km
ODGRAIL-GWA-CALC-0025	Power Calculations - Ferguson River Backup Creek Northern Indicator 2507.713km
ODGRAIL-GWA-CALC-0026	Power Calculations - Cullen River SFD 2511.0km
ODGRAIL-GWA-CALC-0027	Power Calculations - Cullen River Northern Indicator 2513.529km
ODGRAIL-GWA-CALC-0028	Power Calculations - Cullen River Southern Indicator 2508.461km
ODGRAIL-GWA-CALC-0029	Power Calculations - Adelaide River SFD 2649.8km
ODGRAIL-GWA-CALC-0030	Power Calculations - Adelaide River Southern Indicator 2647.247km

ODGRAIL-GWA-CALC-0031	Power Calculations - Adelaide River Northern Indicator 2652.249km
ODGRAIL-GWA-CALC-0032	Power Calculations - Elizabeth River SFD 2736.1km
ODGRAIL-GWA-CALC-0033	Power Calculations - Elizabeth River Southern Indicator 2733.561km
ODGRAIL-GWA-CALC-0034	Power Calculations - Elizabeth River Northern Indicator 2738.651km
Plans	
NRG-GWA-LX-GWA/TCP/002	Northern Territory Stream Flow Detector Installation Test & Commissioning Plan
GWA-07-02-01	Northern Territory Level Crossing Upgrade Project Safety Management Plan
GWA-07-02-02	Northern Territory Level Crossing Upgrade Project Environmental Management Plan

19 Appendices

19.1 Appendix A – Darwin Climate Averages

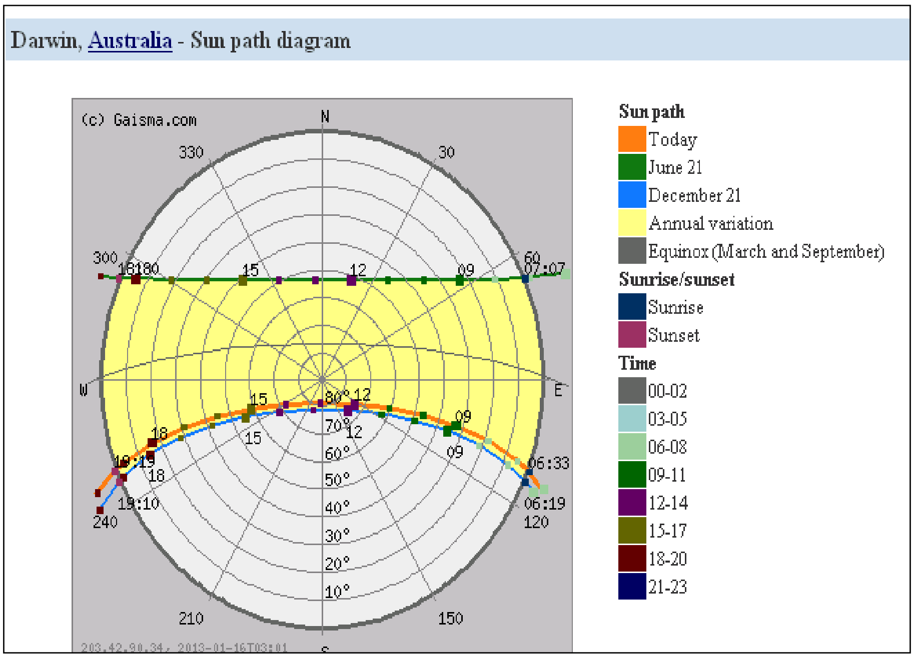
Darwin Climate Averages



Information from Bureau of Meteorology (Monthly Mean Maximum Temperature 2013)

Month	ave temp per month (°C)	Deficiency (%)	average clear days
January	34.6	4.32	1.9
February	33.9	4.005	1.7
March	34.2	4.14	5.4
April	34	4.05	10.1
May	32.1	3.195	17.5
June	30.1	2.295	19.6
July	30.4	2.43	22.2
August	32.3	3.285	23.3
September	35.8	4.86	18.1
October	37.7	5.715	13
November	37.4	5.58	5.3
December	35.9	4.905	2.7

Sun path diagram of Darwin



19.2 Appendix B – Relay Description

Relay	Meaning	Function
SFDPR	Stream flow detector relay	This relay is the energised while the SFD is down
SFDPZR	Stream flow detector repeater special relay	This relay is de-energised whilst the SFD is down
SFDPZ1R	Steam flow detector repeater special relay one	This relay is de-energised whilst the SFD is down
PFR	Power finder relay	When this relay is energised it provides power to the system

19.3 Appendix C – Certificates

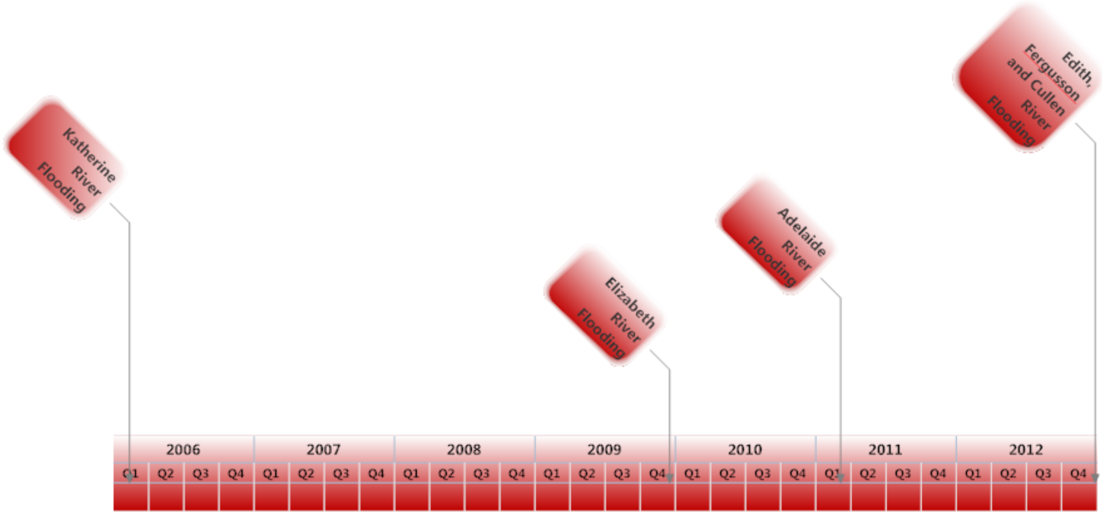
19.3.1 G&W Track Awareness Certificate II in Transport and Distribution (Rail Infrastructure)

The G&W Track awareness provides the skills and knowledge to allow participants to contact Transport Control for authorisation to be on the track or within three (3) metres of the nearest rail for walking inspection purposes only.

The course covers safety, level of work permitted, identifying trains, and actions required, speaking to Transport Control, reportable occurrences, drugs & alcohol, hand signals and level crossing protection.

19.4 Appendix D – History of Flooding

The figure below displays a timeline of flooding events that have occurred with Rivers involved with this project. It shows that each River has flooded exactly once since 2006.



19.5 Appendix E- Power Calculations

These calculations were based on the ODG Power Calculation spread sheet. (Millmen, Power Calculation, 2012).

The total load per day is calculated by using the following equation:

$$load\ per\ day\ (Ah) = (load(A))(Time\ on\ per\ day\ (hours))$$

The battery capacity with 80% depth of discharge (DOD) is calculated by:

$$battery\ with\ 80\%\ DOD = \frac{battery\ capacity}{0.8}$$

The actual battery bank capacity is calculated by:

$$actual\ battery\ bank\ capacity = (capacity\ of\ single\ battery)(number\ of\ batteries\ in\ battery\ bank)$$

The array-to-load ratio is calculated by:

$$Array - load\ ratio\ =\ 1 + \frac{total\ \ days\ \ backup}{total\ \ days\ \ to\ \ full\ \ recovery\ \ with\ 80\%\ discharge}$$

The array to load ratio is essentially the proportionality between the power being provided by the solar panels and batteries against the power being used within the system.

The minimum charge required per day is calculated by:

$$minimum\ charge = \frac{(daily\ load + 10\%)}{charge\ efficiency}$$

The solar powered warranted output power is calculated by:

$$solar\ powered\ warranted\ output\ power =\ (Solar\ Panel\ Minimum\ Warranted\ Power)(solar\ panel\ warranted\ percentage)$$

The number of solar panels is calculated by:

$$number\ of\ solar\ panels = \frac{(backup\ battery\ voltage)(min\ charge\ per\ day)}{(solar\ power\ warranted\ output\ power)(min\ hours\ of\ full\ sunlight)}$$

The maximum current output for 12V output is calculated by:

$$\max current\ for\ 12V\ output = (max\ current\ for\ 24V\ output)(2)$$

The maximum possible current from whole Solar Array at 12V output is calculated by:

$$\max current\ for\ whole\ 12V\ Array = (max\ current\ for\ 12V\ output)(number\ of\ solar\ panels)$$

19.6 Appendix F – Scope of Works (SOW)

RAIL
ELECTRICAL &
COMMUNICATIONS
ENGINEERING

SOW

NORTHERN TERRITORY STREAM FLOW DETECTORS (SFD)
DESIGN, SUPPLY, CONSTRUCT AND COMMISSION

.

Document Number: ODGRAIL-GWA-CALC-0035
Contract Number: Contract Number

Revision	Issued	Reason	Prepared	Checked	Approved
A	29-08-2012	Review	CM	JM	

1 Contents

2 TITLE

STREAM FLOW DETECTORS (SFD)
DESIGN, SUPPLY, CONSTRUCT AND COMMISSION

3 CONTRACT AND DOCUMENT NUMBER

CONTRACT NUMBER:
DOCUMENT NUMBER: ODGRAIL-GWA-CALC-0035

3.1 Definitions and abbreviations

Terminology	Definition
Client/Company	GWA (North) Pty Ltd
Contractor	O'Donnell Griffin
Safe working	The system of safely organising train movements on a railway network
Procedure	Specified way to carry out an activity or process
Process	Set of interrelated or interacting activities which transforms inputs to outputs
Aspect	What the signal displays (red, yellow, green)
Indications	What the aspects means (its definition)
Hazard	Anything with the potential to cause harm to a person, equipment or the environment.

Abbreviation	Name
ODG	O'Donnell Griffin
PPE	Personal Protective Equipment
SER	Signalling Equipment Room
LOC	Location Case
HSE	Health, Safety & Environment
FAT	Factory Acceptance Testing
SAT	Site Acceptance Testing
SEAR	Safetran Event Analyser & Recorder
GWA	GWA (North) Pty Ltd/Genesee & Wyoming Australia Pty Ltd
GCP	Grade Crossing Predictor
TC	GWA Transport Control
JHA	Job Hazard Analysis
ITP	Inspection Test Plan
ATW	Authority to Work
SOW	Scope of Work
LX	Level Crossing

4 SCOPE

4.1 General

In order to reduce the risk of derailments on major bridges, SFD sites shall be installed and commissioned.

The Scope of work involves the minimum requirements to carry out the design, supply, install and commission the Stream Flow Detections and ensure 10 days of backup power supply at each site. The Contractor shall provide a fully functional solution that is standardized, well documented and entirely operational. Works include design, supply, construction and commissioning at all the sites listed below:

- Elizabeth River – 2736.1km
- Adelaide River - 2649.8km
- Cullen River - 2511.0km
- Fergusson River – 2505.2km
- Edith River – 2490.8km
- Katherine River - 2448.1km

The work is to be delivered as a variation to the existing contract between ODG and GWA for the Northern Territory Level Crossing Upgrade Project.

5 Work Included – Establishment

5.1 General

Unless otherwise excluded, the Work under the Contract shall include, but not be limited to the supply of all administration, labour, supervision, equipment and fittings, wiring and all minor incidental work, accommodation for site visits and generally the supply of all office and workshop equipment and consumables that are required, specified or unspecified, for the proper and timely completion of the Work under the Contract. It includes the following works:

1. Provide new or modify asset protection location and associated equipment to monitor and provide SMS and email alarms back to nominated GWA personnel, including TC, for SFD.
2. Provide new or modify existing radio communication networks.
3. Provide new or upgrade existing solar arrays and battery capacity to increase the power supply for modified signal and asset protection locations.

The contractor shall plan to undertake the Works so that is has been tested and is ready for commissioning at a time that meets the Company supplied Milestone Dates and schedule and is suitable for the Company operating requirements.

5.2 Health & Safety Management Plan

The Contractor shall be responsible for the safety of the work under the Contract, and its personnel. The Contractor shall ensure that at all times its employees, and its Subcontractor's employees engaged in the performance of the Works, observe a safe system of work which complies with relevant Acts, Regulations, By-laws, Ordinances, Rules of Order and all Company standards, procedures and requirements, and adopts known and accepted safe working practices. The Contractor shall provide all of its employees, and its Subcontractors employees engaged in the performance of the work, all appropriate personal protective equipment, appropriate training in the utilisation of the equipment and safety information.

5.3 Facilities

The Contractor shall provide, maintain, move as required during the construction of the Works, and remove on completion, all necessary temporary offices, buildings, potable water, ablutions, water closets, sheds, stores and storage areas.

The Contractor shall be responsible for the supply, operation, maintenance and demobilization of all power sources as required by the Contractor including that required during the period of the Works.

The Contractor shall not erect any structures or lay out any storage area, within the Site, without the Company Representative's prior written approval. Such approval shall not relieve the Contractor of its responsibility for positioning temporary structure clear of the Works or other obstructions.

All Site facilities shall be in good condition and approved by the Company Representative prior to mobilisation to Site. The location for each facility unit shall be approved in writing by the Company Representative, and shall be accessible by motor vehicle from adjacent roads.

All Site facilities shall be constructed and secured against cyclonic wind conditions.

5.4 Train Notice

A train notice shall be issued to ensure the train drivers are aware of the activity in the corridor.

5.5 Civil

The Contractor shall prepare and submit all required permit applications to the Company Representative with minimum of (7) working days (Monday to Friday) prior to notice including but not limited to; working at heights, Excavation, Authority to Work, Confined Space, Vicinity Permit and Hot Work. All permit applications shall be accurately complied and submitted. Inaccurate applications shall be returned to the Contractor, who shall amend them and resubmit. Any subsequent submission shall be reviewed by the Company Representative.

5.6 Structural

Where required, the Contractor shall design, supply, manufacture, assemble and install approved suitable equipment enclosures. The contractor shall provide all loading, transport and unloading for equipment enclosures including and all other associated materials.

Design of all equipment enclosures and precast equipment foundations shall be submitted to the Company Representative for approval prior to any fabrication and construction related activities being carried out.

All new structures, (i.e. masts) shall be certified and approved by a qualified structural engineer as meeting the current Australian standards. The certification shall address the adequacy of the proposed arrangements for the specified application, having regard for the wind terrain category. All foundations shall be designed to a minimum rating of cyclonic Region ‘C’.

The Contractor shall supply, manufacture, assemble and install approved indicators which shall include masts and bases. . Each indicator can display a YELLOW or GREEN Aspect. If the Contractor nominates to use a different mast type, the design must be submitted to the Company Representative for approval.

5.7 Electrical

The Contractor shall supply design drawings of the equipment and power designs. These design drawings shall be approved by the Company Representative prior to any work being carried out.

All work shall be as per the approved design and drawings. All electrical work shall be installed in accordance with the relevant Australian standards, Federal and state regulations, GWA specification, and best electrical industrial installation practices.

For each Site the Contractor shall construct, assemble and install the approved control and power equipment, including remote control telemetry, and radio equipment into the equipment racks and wire in accordance with the approved design.

5.8 Traffic Management

The Contractor shall submit for approval a comprehensive Traffic Management and Transportation Plan (TMTP) prior to mobilisation and Site Specific Plans (Traffic Control Plans / Diagrams – TCPs) prior to construction. The Contractor shall ensure that all risks to, and arising from, the operation of traffic are effectively managed for the duration of the Contract and any extensions thereto. The Contractor shall also give attention to the management of construction traffic and of traffic not associated with the Works.

The Contractor must specifically address the planned approach and method for crossing the rail line at existing level crossings. Crossing of the rail is restricted to existing level crossings only, and then to be strictly in accordance with the Company's Railroad Operating Rules. Level crossing traffic controllers must be in attendance at all times when Constructional Plant is using level crossings.

These plans may be subject to change during the course of the work due to the Company's operating requirements.

These plans shall include plans to advise motorists of the changes to the Company's access road required during the construction works.

When working on, or adjacent to roads, rail crossings and or structures under the governing authority of the NT Government or local council the Contractor shall be deemed to have allowed for the engagement of accredited the NT Government or local council traffic Controllers.

Without limiting the Contractor's statutory obligations, the Contractor shall comply with and shall be deemed to have allowed for all of the traffic management requirements contained in the Contract.

5.9 Environmental and Heritage

Without limiting the Contractors statutory obligations, the Contractor shall comply with and shall be deemed to have allowed for the environmental requirements contained in the Contract.

The Contractor shall specifically ensure that:

Storage sites for hazardous materials (such as fuels and oils) and plant maintenance areas are confined to specific identified and approved locations.

Appropriate protection measures are in place to deal with spillage and subsequent clean-up.

Dust control procedures are in place at all times to ensure airborne dust is kept to a minimum and that compliance with all statutory and Company requirements are achieved.

No ground disturbance works are to take place before the relevant Site Vegetation Clearance Permits, Excavation Permits and Authority to Work Permits have been issued.

Work methods, dust control, etc for asbestos form materials in cuts are in accordance with the legislation and guidelines.

All applicable Company environmental requirements shall be met at all times.

At all times all ground disturbances occur only within the rail lease. If unsure the Contractor shall confirm with the Company Representative prior to disturbing any area. The Contractor shall make itself aware of the special land tenure conditions that apply for this area.

5.10 Staffing

5.10.1 General

The Contractor shall supply, suitable and experienced personnel required to undertake the Works and as otherwise required by the Company Representative. For all phases of the Works the Contractor shall employ suitably qualified resources.

5.10.2 Management

Sufficient project management, construction management, professional and administrative personnel to manage and control the Works including the environmental, safety and heritage requirements, and to ensure that the construction activities and project deliverables are undertaken and completed in accordance with the agreed program and quality of work.

5.10.3 Supervision

Sufficient supervisors trained to oversee and control construction of the Works.

5.10.4 Construction

Sufficient and experienced construction personnel to ensure that the construction activities are undertaken and completed in accordance with the agreed program and quality of workmanship.

5.10.5 Electrical

Electrical work shall be undertaken by personnel who hold a valid ‘A’ grade electrical licence: Only qualified signal technicians who possess a valid ‘A’ grade electricians license, and have been approved by the Company Representative, shall carry out any wiring, terminations and adjustments, both in the factory and field.

5.10.6 Safe Working Procedures

The Contractor shall provide suitably qualified personnel trained in the Company’s’ Safe Working Procedures to ensure contact is maintained at all times within five (5) metres of any track deemed as being operational.

5.10.7 Design, Installation, Testing and Commissioning

The Contractor shall provide suitably qualified personnel for design, installation, testing and commissioning staff to ensure that the construction activities and Project deliverables are undertaken and completed in accordance to the Company’s high level commissioning schedule.

All design, testing and commissioning shall be undertaken by the Contractor using qualified Railway Signalling Engineers.

5.11 Plant and Equipment

The Contractor shall supply, mobilise, operate, maintain and demobilise all plant that is suitable and in good working order (including maintenance equipment) required to construct the Works as otherwise required by the Company Representative.

The Contractor shall thoroughly clean all Constructional plant equipment to remove mud, soil and any other foreign material matter prior to transportation to Site. The Contractor must also submit a weed inspection and wash down certificate to the Company Representative, prior to mobilisation, to demonstrate compliance with Company environmental management requirements.

The Contractor shall submit certification documentation to the Company Representative prior to mobilisation confirming that all mobile Constructional Plant sent to Site is roadworthy, carries all necessary statutory certifications and complies with all site requirements. The Contractor shall not use any item of plant or equipment on Site until inspected by the Company Representative and formally approved for sue on Site.

Where specialised test tools are to be sued then these test tools shall have been validated in their own right. All tool validation and calibration certificates shall be made available prior to the commencement of testing. Copies of all tool validation and calibration certificates shall be submitted along with the test and commissioning results.

6 Work Included – Contract Wide

6.1 Design

6.2 Design

The Contractor shall produce and provide to GWA all the designs necessary to complete the Works. This shall include but not be limited to:

- Power calculations, including level crossing load calculations
- Design to support FAT, including connectivity drawings, wiring diagram(s)
- Interface connectivity diagram(s)
- System interface requirements
- Cable running plans
- Construction conduit layout plans
- Equipment and product mechanical design
- Verification and validation plans
- Product and system safety case documents

The methods to be used and the processes to be adopted to develop, control, verify and validate the designs throughout the lifecycle of the Project shall be in accordance with Contract requirements and a series of design process and requirement documents to ensure that designs are rigorously controlled in line with Australian Standard design quality control processes and procedures. As a minimum, all designs shall be carried out in accordance with Design Management Plan, Design Processes and Resource Requirements.

The Contractor shall be issued the documents and typical designs, which could include:

- Functional specification(s)
- Typical equipment layout drawings
- Plan and profile drawings
- Track schematics

Where any existing system, circuitry or equipment requires being altered to or interface to, it shall be the responsibility of the Contractor to undertake a detailed site survey, site correlation, site configuration control checks to establish a baseline for all new and modified designs (wiring, software and data).

6.3 Design drawings and approval process

The design drawings for any proposed circuits, software, new equipment, existing equipment, cable layouts, foundations or mast apron arrangements shall be submitted by the Contractor, to the Company Representative for review.

6.4 Civil

The Contractor shall complete all minor civil works in accordance with the requirements detailed in the Contract which includes but is not limited to;

Cable trenching for pit/pipe for signals and electrical including pit/pipe from main fibre pit to signal enclosure and; under road and under track crossings, installation of cable pits, clearing, rock excavation, borrow, backfill, dewatering, dust suppression, compaction and clean up. This includes all trenching pit and pipe from the main fibre pit to the equipment enclosure and from the mains switchboard to the equipment enclosure.

The Contractor shall supply a suitable transportable water storage facility for use to aid in compaction.

All earth pits shall be trafficable and of a string and durable nature. The Contractor shall submit earth pit designs proposed to be used on the project to the Company Rep for approval prior to any fabrication or procurement.

6.5 Structural

The Contractor shall complete all structural works in accordance with the requirements detailed in the Contract which includes but is not limited to;

- Undertake all structural earthworks e.g. installing conduits for all external cabling
- Supply and Installation of all trenching/pitting, cabling needed to complete the Works
- Supply and install lightning protection
- Supply and install solar array frames (complete with solar panels). Solar panels shall be mounted on LOC roof or pole mounted with anti theft fittings
- Supply and install six (6)metre break back mast for radio antennas
- All foundations shall be supplied and installed to a minimum rating of cyclonic Region 'C'
- Supply and install the SFD tanks and switches

7 Electrical

7.1 Power

This Work package requires a fully operation SFD and associated supporting infrastructure for each site.

The work shall include:

- Installation of new cabling, connections etc throughout the battery limits of the project.
- Where cables are run above the ground they shall be protected in anaconda conduit. Where cables are run below ground they shall be run in 100mm orange conduit, with suitable pits at each end of the conduit run and at any change of direction.
- Supply and install the solar panels and batteries to suit the power requirements of each SFD site to ensure 10 days of backup battery power supply. The Contractor shall provide a switched voltmeter in a separate lockable enclosure for all battery power supplies.
- Supply and install surge protection.

7.2 Communications

The Contractor shall stipulate to supply or re-use existing radio telemetry equipment for temporary stage works only. Where final installation is required on radio new equipment shall be provided. The relocation, re alignment and RF survey along with any programming requirements shall be allowed for and carried out by the Contractor. This includes all equipment, masts and enclosures as included in the work breakdown.

7.3 Indicators

The Contractor shall supply and install Westinghouse 212mm 2 aspects Green over Yellow indicator mounted on break back masts. The preferred type is Westinghouse easy access signal mast. Indicators shall be permanently illuminated. Yellow shall be indicated representing the Train Driver is required to reduce speed and green indicating the route is clear

Indicators are to be installed on the Driver's Left hand side approaching the SFD unless approved otherwise by GWA.

The Contractor shall provide signage for the Indicators. Signage must include the river name (the name shall be shortened if required) and the text SFD. Text shall be black on reflective white background.

7.4 Radio Works

The contractor shall provide an antenna and cable form the mast to the LOC. The Contractor is responsible for supply, installation and commissioning of the radio equipment that is required for all sites.

7.5 Additional Communications Requirements

Within the battery limits of this Scope, end to end Data network quality criteria are to be within the specification and requirements for the effective operation of the project.

7.6 Fabrication and Wiring

The Contractor shall undertake design, fabrication, testing, construction and commissioning works in accordance with the documentation and drawings and Contract requirements.

All pre wire rack wiring, electrical fabrication and FAT shall be executed offsite. The Contractor shall provide all transport of FAT tested and accepted equipment to its holding area and location of final installation. Allowance shall be made to store the equipment until it is ready for installation onsite.

The wiring colouring shall be consistent throughout the project and compliant with Contract requirements. If there is any confusion with the colouring of cables/wiring the Company Representative shall be notified before the tender is awarded.

8 Testing and Commissioning

The Contractor is to provide recommended Acceptance Testing checklists for both Site Acceptance Testing and Final Project Acceptance testing. Such checklists shall embody the manufacturers' recommendations and key requirements of this Scope including physical and electrical requirements.

All the designs and products supplied by the Contractor or free issued under he Contract shall be subjected to a series of tests. The objective of the tests shall verify and validate the products and systems to ensure that they conform with:

- Standards and specifications
- Defined functional requirements
- Reliability, availability and maintainability indicators
- Safety integrity requirements as specified for a system or product.

The Contractor shall develop a test and commissioning management plan which forms the overarching document for each commissioning phase. The test and commissioning the plan shall be submitted by the Contractor to the Company Representative for approval for each site and phase of testing and/or commissioning activity prior to the commencement of the tests or commissioning.

In addition, the Contractor shall develop Site Test Plans. The testing and commissioning plans shall be submitted by the Contractor to the Company Representative for approval each site and phase of testing and/or commissioning activity prior to the commencement of the tests or commissioning. The test and commissioning plan shall include copies of all test certificates, ITPs and documentation (including pass/fail criteria) to be used during the tests. The plan shall include the work covered by the SOW for this Contract, and also with respect to interfaces to the other Contractors works.

8.1 Site Acceptance Testing

Upon completion of each SFD site installations, SAT shall consist of:

- SFD operational test and Systems Integration tests.
- Sign-off each individual SFD site acceptance checklist by the Contractor and Company Representative.

8.2 Final Project Acceptance Testing

Upon completion of all SAT and checklists to the satisfaction of the Company Representative, the SFDs are to be proven in-use.

Once all systems under the Contract have been tested and accepted, and those which interface with the Works have been tested and accepted, the Works of phase of the work can be commissioned.

8.3 Enabling and Stage Works

Work shall include the early relocation of existing cables and pits to allow the construction of earthworks and track as detailed within the stage works drawings, as issued, and in accordance with the project schedule. Existing LOCs may need to be temporarily relocated prior to removal to enable sufficient room for a new LOC. Coordination shall take place with the Company for request of shutdowns and possession times between trains. All relocated equipment shall be commissioned so that the safety of the system is not compromised and there is no impact to the proposed train movements/business requirements. The Contractor shall allow for the resources required to relocate the masts, terminate cables, test cables, set to work and commission all relocated equipment. This work shall be undertaken as required in conjunction with the main signalling installation work.

8.4 Installation, Operation and Maintenance Manual

The Contractor shall supply Site specific operation and maintenance manuals for each new location.

Manuals shall be easy to handle and shall allow for the addition of amendments- as such, a secure loose-leaf folder format is preferred.

Covers shall be of durable material, strong and suitable for use in the field. Printed on the front cover and spine shall be the descriptive title of the equipment or subject together with identification number.

Each volume shall contain an index to the sections included within the manual/folder.

Explanations shall include drawings and photograph. Drawings should fold clear of the text. Terms and abbreviation symbols shall appear in a glossary of terms placed in the front of each volume.

Different sections of the volume shall be separated by dividers with an edge strip which is clearly visible with the book closed.

Installation instructions shall detail the complete mechanical and electrical installation of the equipment. All mechanical components of the mounting arrangements shall be completely listed and clearly depicted in drawings and photographs. The handbooks must include complete details of any alternate equipment arrangements. A layout diagram shall be provided that is fully dimensioned and with all sub units, terminal, test points etc, labelled for identification.

Drawings shall be provided showing details of cable entries, interfacing requirements such as cabling between system components and load, and any other features requiring special attention.

Maintenance instructions shall be of sufficient detail to allow the Company Representative to fully test, repair and otherwise maintain the equipment.

Handbooks shall contain sections covering the following aspects:

- Initial system testing and commissioning of new equipment
- Techniques for testing

- Description of equipment functions and circuits
- Performance specifications
- Drawings and photographs

8.5 Refurbishment and Re-use of Existing Equipment

The refurbishment or re use of equipment shall not be used unless otherwise instructed to within the work breakdown section of the SOW. This includes but is not limited to; all equipment enclosures, earthing, cabling, foundations, signals, pits and pipes and level crossing equipment.

8.6 Recovery of Redundant Materials and Final Cleanup

Restore and compact any disturbed ground to a compaction level the same or greater than the surrounding area. Remove any construction debris and excavation material, for which the Contractor is responsible, from the Site and dispose of in an approved manner.

At completion of the Works the Contractor shall clean all of the installed LOCS and equipment to remove scuff marks, mud dust and dirt, repair scratches and remove all adhesive tape and glue marks. All loose debris (including inside the document drawer) resulting from the Works shall be removed including swarf and metal filings, cable scraps wrapping materials and equipment packaging.

Uncontaminated and lightly compacted stone or gravel shall cover the surface of the ground around equipment cases, around and under solar panels, and all other wayside equipment.

Any equipment made redundant during the site works and after the final commissioning of the signalling is to be recovered, loaded, transported and laid down at an area nominated by the Company Representative. All redundant pits shall be removed. Any cables installed in conduits that are made obsolete shall be recovered.

9 Work Breakdown Area

The SFD's shall be provided at the following locations:

- Elizabeth River – 2736.1km
- Adelaide River - 2649.8km
- Cullen River - 2511.0km
- Fergusson River – 2505.2km
- Edith River – 2490.8km
- Katherine River - 2448.1km

9.1 Elizabeth River – 2736.1km

9.1.1 Southern Indicator

The Contractor shall supply and install SFD indicator and associated location box and radio equipment on the West side of railway at Chainage 2733.561.

9.1.2 SFD Tank

The Contractor shall Install Stream Flow tank in the North West quadrant of the Level Crossing, adjacent to existing rock protection, with activation occurring when water reaches the underside of the bridge girders at the abutments.

The Contractor shall trench approx 150 metres to the existing Elizabeth River Boat Ramp Road Level Crossing Equipment hut.

The Contractor shall provide an input for the SFD in the existing Elizabeth River Boat Ramp Road Level Crossing SEAR.

The Contractor shall supply and install radio equipment inside existing equipment room.

The Contractor shall supply and install 6 Metre Break back communications mast.

9.1.3 Northern Indicator

The Contractor shall supply and install SFD indicator and associated location box and radio equipment on the East side of railway at Chainage 2738.651.

Communications mast on top of cutting with co-ax installed in steel conduit or pipe secured to the face of the cutting.

9.2 Adelaide River - 2649.8km

9.2.1 Southern Indicator

The Contractor shall supply and install SFD indicator and associated location box and radio equipment on the West side of railway at Chainage 2647.247.

9.2.2 SFD Tank

The Contractor shall supply and install Stream Flow tank South East quadrant of the bridge approx 300 metres from the existing Dorat Rd Level Crossing Equipment hut.

The Contractor shall supply and Install SEAR with GSM Modem in existing Dorat Rd Level Crossing Equipment hut incorporating the level crossing reporting functions; this will require an ILOD and communications module for the GCP3000. Provide an input for the SFD.

The Contractor shall install an additional 6 Metre Break back communications mast and data radio at the existing Dorat Rd Level Crossing.

The Contractor shall install radio equipment inside the existing Dorat Rd Level Crossing equipment room (a radio link between the Stream Flow tank and equipment in the existing Dorat Rd Level Crossing Equipment hut is required) and replace the battery bank for the increased load. All equipment shall be FAT tested prior to transport and installation.

9.2.3 Northern Indicator

The Contractor shall supply install SFD indicator and associated location box and radio equipment on the East side of railway at Chainage 2652.249 opposite Telstra Marker ADI-ADRV-2000_M015.

9.3 Cullen River - 2511.0km

9.3.1 Southern Indicator

The Contractor shall supply and install SFD indicator and associated location box and radio equipment on the West side of railway at Chainage 2508.461.

9.3.2 SFD Tank

The Contractor shall install a new LOC and Stream Flow tank on the East side of the Railway adjacent to existing flow detector owned by the NT Government, with activation occurring when water reaches the underside of the bridge girders.

The Contractor shall Install 6 Metre Break back communications mast.

9.3.3 Northern Indicator

The Contractor shall supply and install SFD indicator and associated location box and radio equipment on the East side of railway at Chainage 1513.529 (subject to assessing and confirming the site).

9.4 Fergusson River (Backup Creek) – 2505.2km

9.4.1 Southern Indicator

The Contractor shall supply andinstall SFD indicator and associated location box and radio equipment on the West side of railway at Chainage 2501.693.

9.4.2 SFD Tank

The Contractor shall Install Stream Flow tank on the East side of the Railway, between the railway and the Old Stuart Highway, approx 75 metres north from Telstra marker FR1GCTK, with activation occurring when water reaches 300mm below the top of formation.

The Contractor shall install and new LOC on the East side of the Railway approx 25 metres North from Telstra marker FR1GCTK in addition to a Standalone SEAR with GSM Modem.

The SEAR shall communicate with Train Control System and provide information for Stream Flow at Cullen River and Fergusson.

The Contractor shall install an eight (8) Metre Break back communications mast.

9.4.3 Northern Indicator

The Contractor shall supply and install SFD indicator and associated location box and radio equipment on the East side of railway at Chainage 2507.713 Opposite Telstra marker FC-FR.

9.5 Edith River – 2490.8km

9.5.1 Southern Indicator

The Contractor shall supply and install SFD indicator and associated location box and radio equipment on the West side of railway at Chainage 2488.000.

9.5.2 SFD Tank

The Contractor shall Install Stream Flow tank in the North East quadrant of the Level Crossing approx 150 metres (trench) from the existing Edith Falls Road level crossing equipment hut, with activation occurring when water reaches the underside of the bridge girders.

The Contractor shall Install SEAR with GSM Modem in the existing Edith Falls Road level crossing equipment hut incorporating the level crossing reporting functions. This will require an ILOD and communications module for the GCP3000. Provide an input for the SFD.

The Contractor shall install a six (6) Metre Break back communications mast.

The Contractor shall install radio equipment inside the existing equipment room and replace the battery bank for the increased load. All equipment shall be FAT tested prior to transport and installation.

9.5.3 Northern Indicator

The Contractor shall supply and install SFD indicator and associated location box and radio equipment on the East side of railway at Chainage 2493.272.

9.6 Katherine River - 2448.1km

9.6.1 Southern Indicator

The Contractor shall install radio equipment inside the existing equipment room and replace the battery bank for the increased load. All equipment shall be FAT tested prior to transport and installation.

The Contractor shall mount the SFD indicator on existing radio mast at the North end of Katherine yard at approximately Chainage 2446.1km. (East side of railway)

9.6.2 SFD Tank

The Contractor shall install the SFD tank in the South East quadrant of the Level Crossing, with activation occurring when water reaches the underside of the bridge girders.

The Contractor shall provide an input for the SFD in the Shad forth Road Level Crossing SEAR.

The Contractor shall install a 6 Metre Break back communications mast.

9.6.3 Northern Indicator

The Contractor shall supply and install SFD indicator and associated location box and radio equipment on the East side of railway at Chainage 2450.645.

10 Battery Limits

Batteries will have a minimum capacity of 10 days back up power.

10.1 Communications

The supply, installation and testing of transmission equipment shall be carried out by the Contractor.

Radios need to be low power consumption and reliable. Master radio at the Stream Flow tank site needs to communicate with 2 slaves at least 2.5Km away in each direction to drive North and South indicators.

The Adelaide River site will require a third slave, only 300metres away, given the radio link between the Stream Flow tank and equipment in the existing Dorat Rd Level Crossing Equipment hut.

10.2 Earthworks

The Contractor shall carry out all civil works required by the SFD.

19.7 Appendix G – Cullen River SFD Design

ODONNELL GRIFFIN RAIL

08-12-02 CAD Work Request Checklist

CAD Work Request Checklist Identification

Refer to Procedure 08-04-02 Work Package Preparation

Project:	SFD Project	Client:	GLJA	Date of Request:	09	10	12
Location:	Standard	Priority:	Medium	Expected Completion Date:	16	10	12

To be filled in by Design/CAD Manager

Engineering Pre-CAD

Document Control Status Checked: NA (has been transmitted to ODG)

Markup Provided is Legible: ☐

Requested Drawing / Sketch Quantity:

Drawing Type:
- New Drawing ☑
- Amend Existing Revision ☐
- New Revision ☐
- Red/Green Works ☐
- Add Signatures Only ☐
- Sketch ☐

Engineer Signature: Charlotte Moss

Date: 09/10/12

Draftsperson Checks

Estimated Time to Complete:

☐ **New Drawing:**
- Drawing Number Issued from Doc. Control ☐
- Created from CAD Conformed Template ☐

☐ **Amend Existing Revision:**
- Aconex Status Checked & DGN Issued To CAD by Document Control ☐

☐ **New Revision:**
- Signatures Added to Previous Revision ☐
- Previous Revision Moved to Digital Archive ☐
- Revision History Removed from Title Block (If Required) ☐

☐ **Red/Green Works:**
- Red/Green Works Drawn on Correct Levels ☐
- Level Symbology Set On & Settings Saved ☐

☐ **Add Signatures:**
- Initials Checked Against Approved Signature Sheet ☐

☐ **Sketch:**
- Sketch Number Issued from Document Control ☐

☑ **All Drawings:**
- Self Checked Against Markup for Completion ☐
- Title Block & Revision Status Info Correct & Status Stamp (if Required) ☐
- Print Set Created ☐
- Drawings Audited / Watermarked ☐
- Files Provided to Doc Control:
  - DGN Qty:
  - PDF Qty:

Draftsperson Sign:

Date:

Engineer Post-CAD

CAD Work Completed: ☐

All Wet Signatures Added: ☐

Photocopy of Wet Signed Drawings Issued to CAD: ☐

Master Wet Signed Drawings Issued to Document Control: Yes ☐ No ☐

Document Control to Send Document: Yes ☐ No ☐

Engineer Signature:

Date:

Document Control

Date Received: | Date Sent: | Transmittal No.:

Doc. Ctrl. Signature:

Date:

FREIGHTLINK
DARWIN
CULLEN RIVER

SFD SITE

SHEET	TITLE	PLAN No.	ISSUE
001	CULLEN RIVER SFD SITE – INDEX	01–3500–0271	0
002	CULLEN RIVER SFD SITE – AREA PLAN	01–3500–0272	0
003	CULLEN RIVER SFD SITE – 12V SOLAR POWER CONNECTIONS	01–3500–0273	0
004	CULLEN RIVER SFD SITE – EARTHING	01–3500–0274	0
005	CULLEN RIVER SFD SITE – SEARII	01–3500–0275	0
006	CULLEN RIVER SFD SITE – 3G MODEM CONNECTIONS	01–3500–0276	0
007	CULLEN RIVER SFD SITE – FUSE & TERMINAL ANALYSIS	01–3500–0277	0
008	CULLEN RIVER SFD SITE – SFD CIRCUITS	01–3500–0278	0
009	CULLEN RIVER SFD SITE – MIRI RADIO MODEM CONNECTIONS	01–3500–0279	0
010	CULLEN RIVER SFD SITE – XANTREX SOLAR CONTROLLER SETUP SHEET	01–3500–0280	0
011	CULLEN RIVER SFD SITE – SPARE	01–3500–0281	–
012	CULLEN RIVER SFD SITE – SPARE	01–3500–0282	–
013	CULLEN RIVER SFD SITE – SPARE	01–3500–0283	–
014	CULLEN RIVER SFD SITE – SPARE	01–3500–0284	–

Rev.	Date	Description	Design	App'd
0	10/10/12	INITIAL DESIGN		

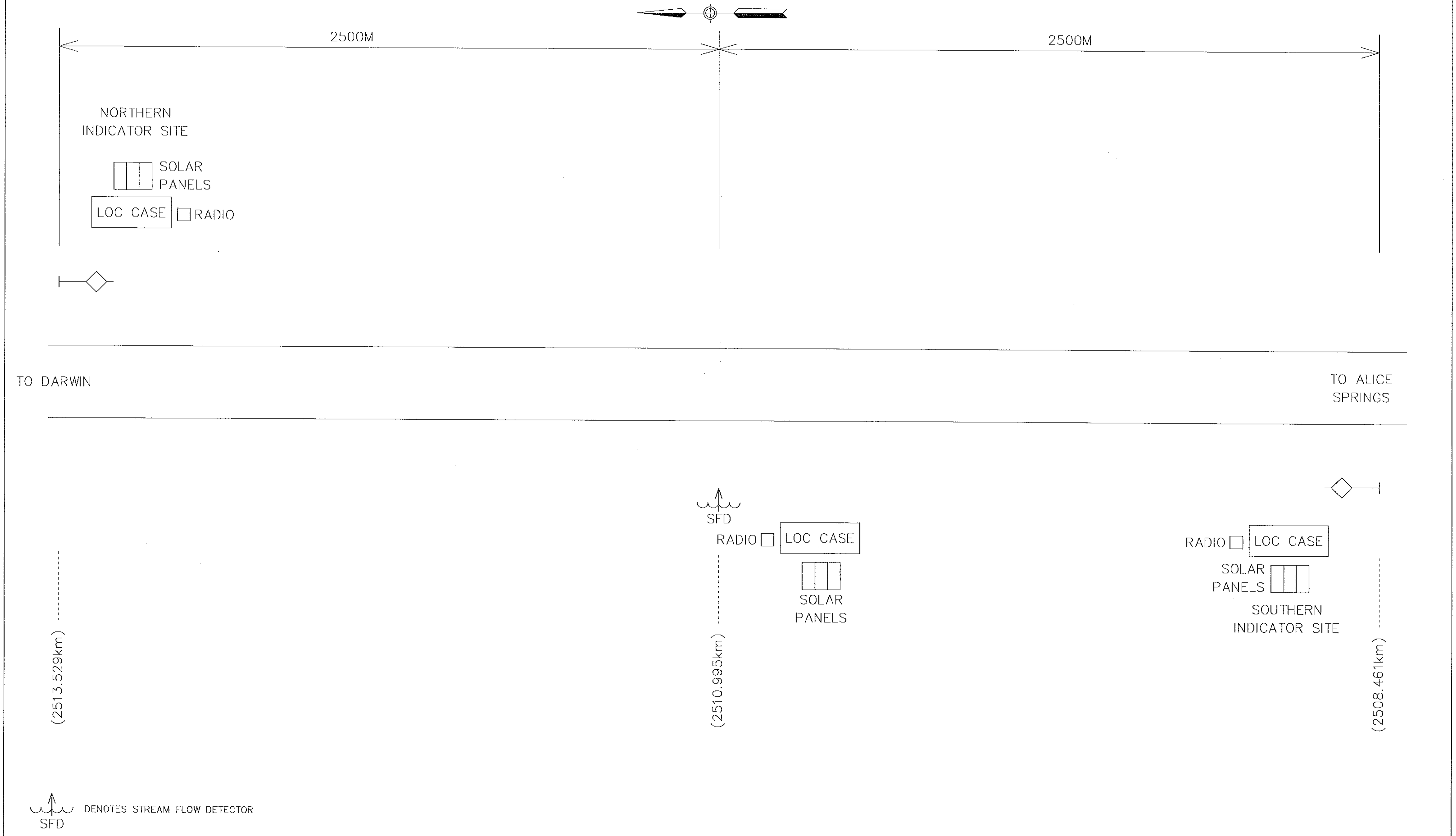
Scale: N/A
Designed:
Checked:
Approved:
Date:

O'DONNELLGRIFFIN

DARWIN
CULLEN RIVER SFD SITE
2510.995Km
INDEX

0

Sheet No.
01–3500–0271



Rev.	Date	Description	Design	App'd
0	10/10/12	INITIAL DESIGN		

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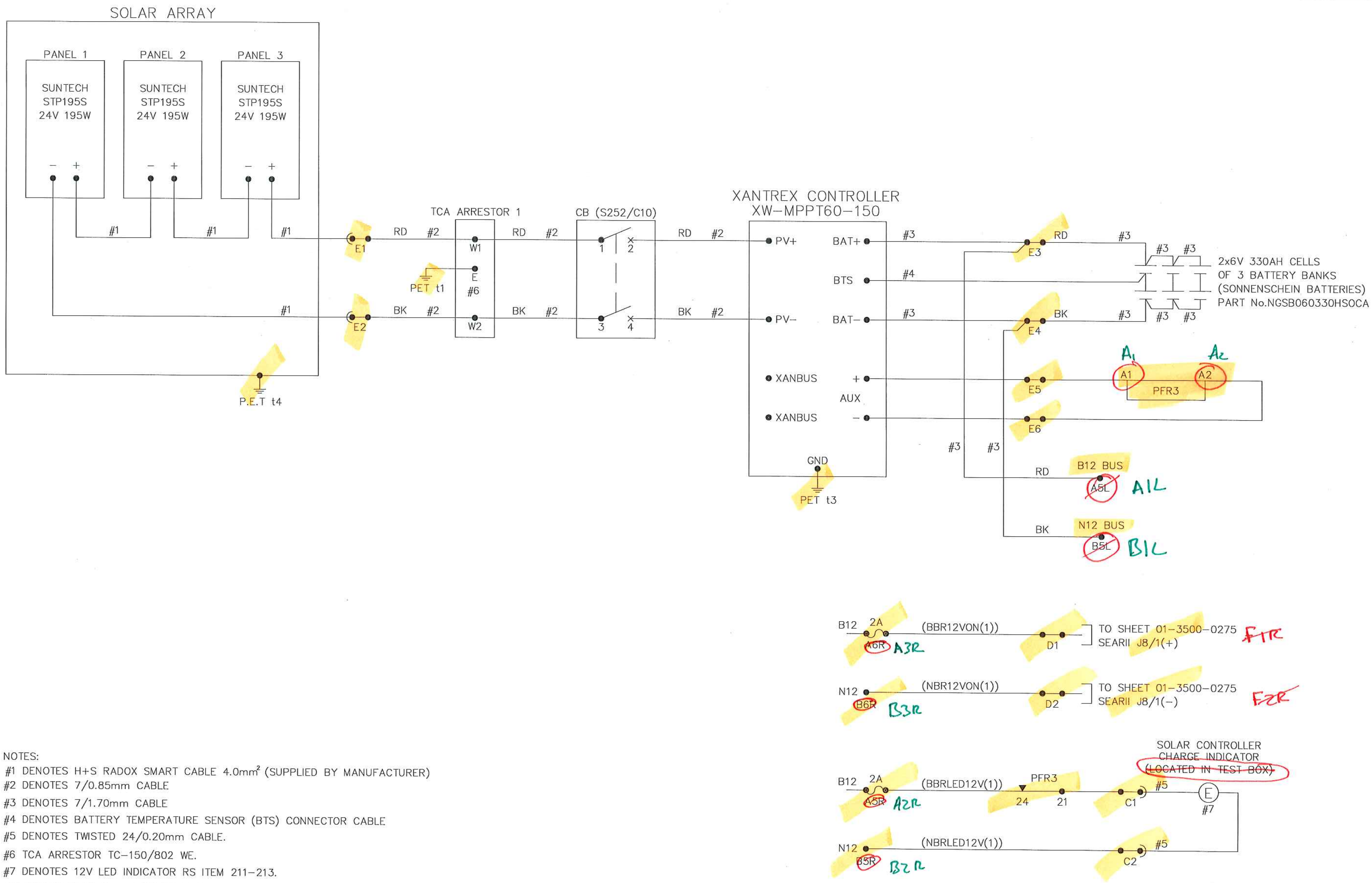
Checked:
Approved:
Date:

O'DONNELLGRIFFIN

DARWIN
CULLEN RIVER SFD SITE
2510.995Km
AREA PLAN

0

Sheet No.
01-3500-0272



NOTES:

#1 DENOTES H+S RADOX SMART CABLE 4.0mm² (SUPPLIED BY MANUFACTURER)
#2 DENOTES 7/0.85mm CABLE
#3 DENOTES 7/1.70mm CABLE
#4 DENOTES BATTERY TEMPERATURE SENSOR (BTS) CONNECTOR CABLE
#5 DENOTES TWISTED 24/0.20mm CABLE.
#6 TCA ARRESTOR TC-150/802 WE.
#7 DENOTES 12V LED INDICATOR RS ITEM 211-213.
ALL WIRING 24/0.20mm UNLESS OTHERWISE SPECIFIED.
SEE XANTREX MANUAL (XW-MPPT60-150) FOR PROGRAMMING INSTRUCTIONS.
EARTH WIRE TO BE GN/YE 7/0.85mm

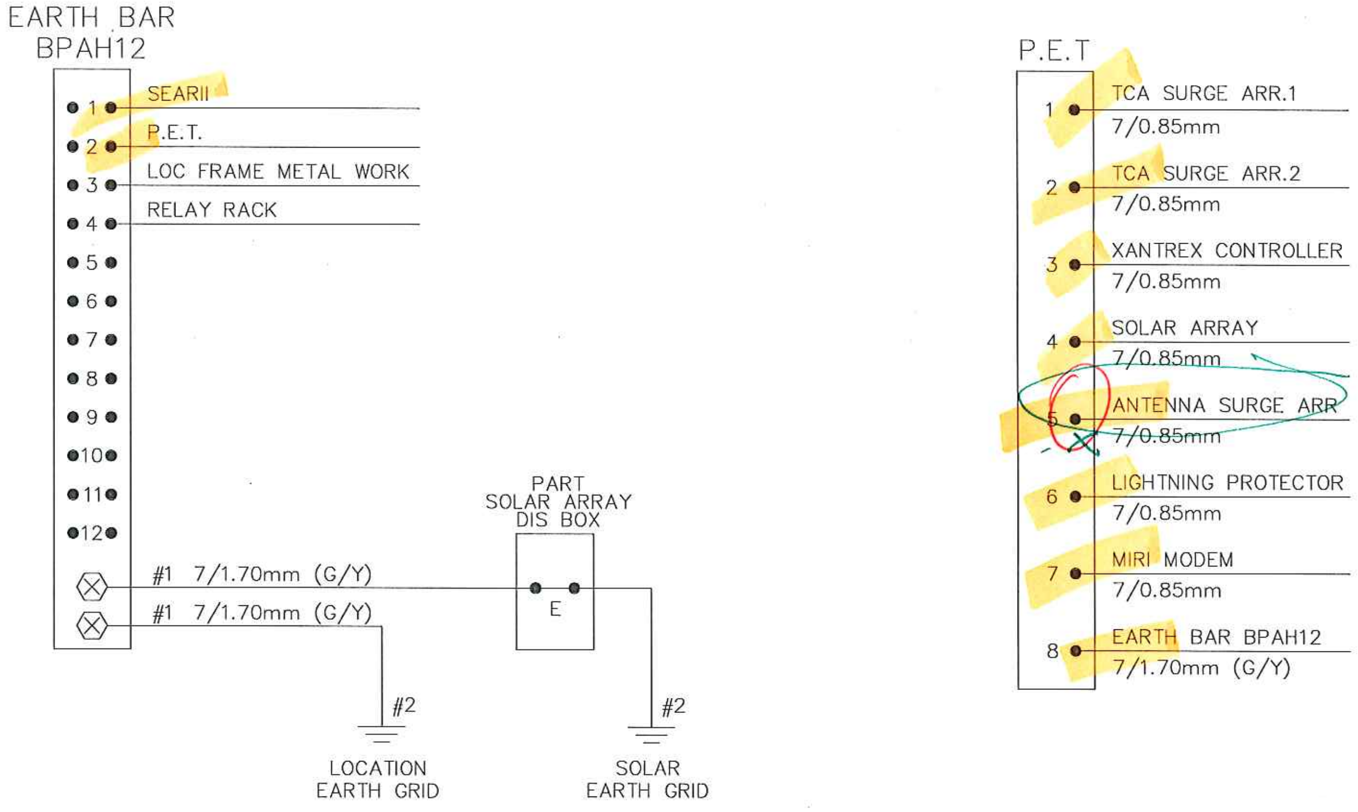
Rev.	Date	Description	Design	App'd	
0	10/10/12	INITIAL DESIGN			Scale: N/A
					Designed:
					Checked:
					Approved:
					Date:

O'DONNELLGRIFFIN

DARWIN
CULLEN RIVER SFD SITE
2510.995Km
12V SOLAR POWER CONNECTIONS

0

Sheet No.
01-3500-0273



#1 LABEL BOTH ENDS OF WIRE "DO NOT DISCONNECT UNLESS SUPPLY IS ISOLATED"

#2 MAIN EARTH TO BE TERMINATED ON THE CLOSEST EARTH MAT ELECTRODE OR INDEPENDENT EARTH AND LABELLED BOTH ENDS OF THE WIRE "MAIN EARTH DO NOT DISCONNECT"

ALL WIRING 24/0.20mm BLACK UNLESS SPECIFIED
ALL EARTH WIRING 7/0.85mm (G/Y) UNLESS STATED OTHERWISE

Rev.	Date	Description	Design	App'd
0	10/10/12	INITIAL DESIGN		

Scale: N/A
Designed:
Checked:
Approved:
Date:

O'DONNELLGRIFFIN

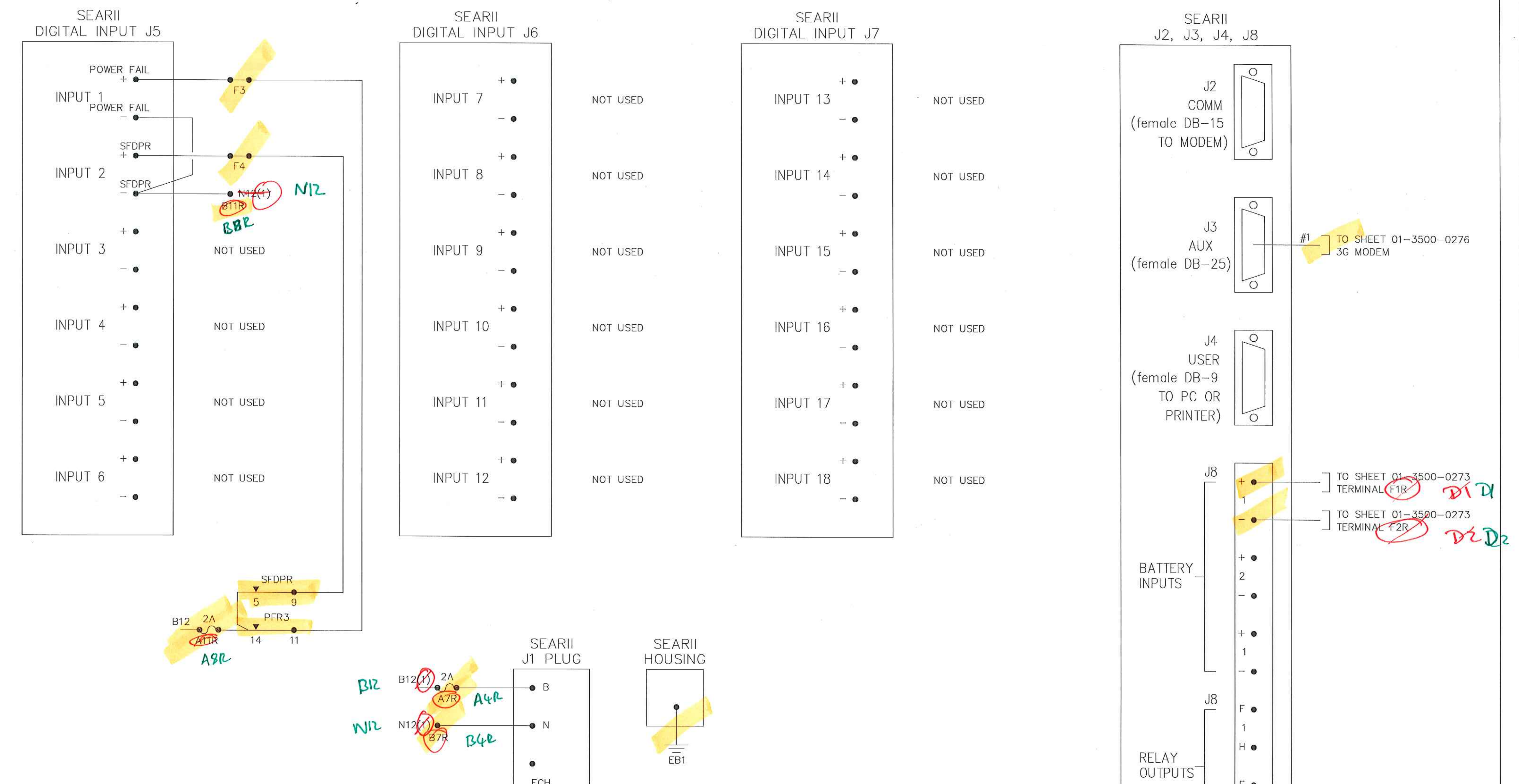
DARWIN

CULLEN RIVER SFD SITE

2510.995Km
12V SOLAR POWER CONNECTIONS

0

Sheet No.
01-3500-0274



TWISTED PAIRS
#1 DENOTES 5 PAIR SCREENED 7/0.25mm
DB25M TO DB15M(HD) CABLE
#2 DENOTES TWISTED 24/0.20mm CABLE
ALL WIRING 24/0.20mm BLACK UNLESS SPECIFIED

Rev.	Date	Description	Design	App'd
0	10/10/12	INITIAL DESIGN		

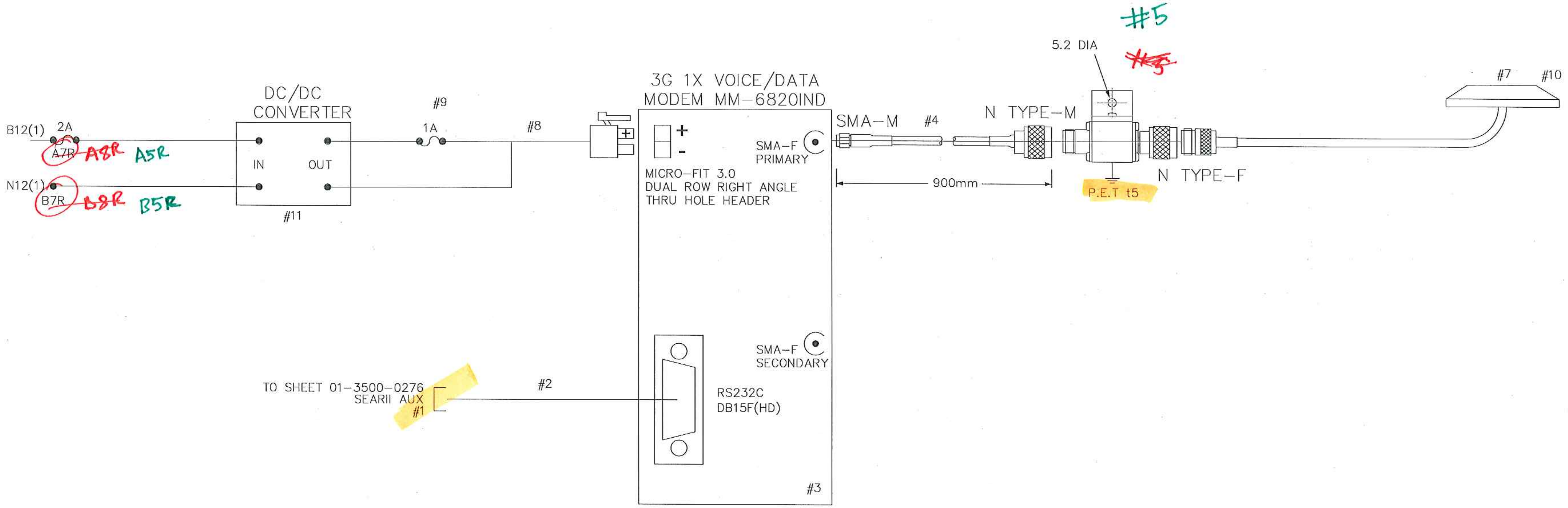
Scale: N/A
Designed:
Checked:
Approved:
Date:

O'DONNELLGRIFFIN

DARWIN
CULLEN RIVER SFD SITE
2510.995Km
SEARII

0

Sheet No.
01-3050-0275



CABLE DETAILS FOR #2

DB25M pin	Signal	Colour	Signal	DB15M(HD) pin
2	TXD	RED	TXD	3
3	RXD	BROWN	RXD	2
4	RTS	BLUE	RTS	7
5	CTS	PURPLE	CTS	8
6	DSR	GREEN	DSR	6
7	GND	YELLOW	GND	14
8	DCD	BLACK	DCD	1
20	DTR	ORANGE	DTR	13
22	RI	GREY	RI	10

SCREENED 5 PAIR
7/0.25mm – 1500mm

DB25M DB15M(HD)

#1 – SEARII UNIT
#2 – 5 PAIR SCREENED 7/0.25 DB25M TO DB15M(HD)
#3 – 3G GENERIC MODEM MM-6820IND
#4 – SMA MALE TO N TYPE MALE CELLFOAM CABLE
#5 – ANTENNA SURGE ARRESTOR POLYPHASER IS-B50LN-C2
#6 – SILICON FILL ON INSIDE OF CASE– NUT REVERSE THREAD
#7 – MAXON C3LA30-BD170 ANTENNA
#8 – TWIN FIGURE 8 13 / 0.20mm
#9 – INLINE FUSE (1A)
#10 – ANTENNA MOUNTED ON ROOF OF HUT
#11 – MASCOT 8862 DC/DC CONVERTER (FARNELL P/N: 118-3943)

Rev.	Date	Description	Design	App'd
0	10/10/12	INITIAL DESIGN		

Scale: N/A
Designed:
Checked:
Approved:
Date:

O'DONNELLGRIFFIN

DARWIN
CULLEN RIVER SFD SITE

2510.995Km
3G MODEM CONNECTIONS

0

Sheet No.
01–3050–0276

	A			B	
	B12			N12	
1	B12	B12		N12	N12
~~2~~ 9		~~BBR12VON~~ SPARE		9	~~NBR12VON~~ SPARE
~~3~~ 10		SPARE		10	SPARE
~~4~~ 11		SPARE		11	SPARE
~~5~~ 2		BBRLED12V(1)	2	2	NBRLED12V(1)
~~6~~ 3		BBR12VON(1)	2	3	NBR12VON(1)
~~7~~ 4		BBRSEARII	2	4	NBRSEARII
~~8~~ 5		BBRDCDC	2	5	NBRDCDC
~~9~~ 6		BBRSFDPR	2	6	NBRSFDPR
~~10~~ 7		BBRMIRI	2	7	NBRMIRI
~~11~~ 8		BBRPFR3/SFDPR	2	8	NBRPFR3/SFDPR

	C			D		E
1	BBRLED12V(1)	#1	1	SEARII J8/1(+)	1	XW60 PV+ (RD)
2	NBRLED12V(1)		2	SEARII J8/1(−)	2	XW60 PV− (BK)
3	BBRSFDPR		3	SEARII J5/1(+)	3	XW60 BATT+ (RD)
4	NBRSFDPR		4	SEARII J5/2(+)	4	XW60 BATT− (BK)
5 5	Spare Spare		5 5	Spare Spare	5	PFR3
6 6	Spare Spare		6 6	Spare Spare	6	NPFR3
7 7	Spare Spare		7 7	Spare Spare	7 7	Spare Spare

RELAY TYPE	FUNCTION	COIL			CONTACT					
		A1	SHT	A2	11	SHT	14	21	SHT	24
FINDER 40.525	PFR3	1	0273	1	1	0275	2	1	0273	1
					SEARII J5/1(+)			SEARII J8/1(+)		

RELAY TYPE	FUNCTION	COIL			CONTACT																								
		13	SHT	14	5	FRONT	9	BACK	1	6	FRONT	10	BACK	2	7	FRONT	11	BACK	3	8	FRONT	12	BACK	4
OMROM LY-4N 4F/B	SFDPR	1	0278	1	1	0275	1			1	0279	1												
					SEARII J5/2(+)					MIRI D.INPUT 1(+)														

#1 DENOTES 2c 7/0.85mm CABLE TO SFD JUNCTION BOX
ALL WIRING 24/0.20mm BLACK UNLESS SPECIFIED
☐ DENOTES JUMPER

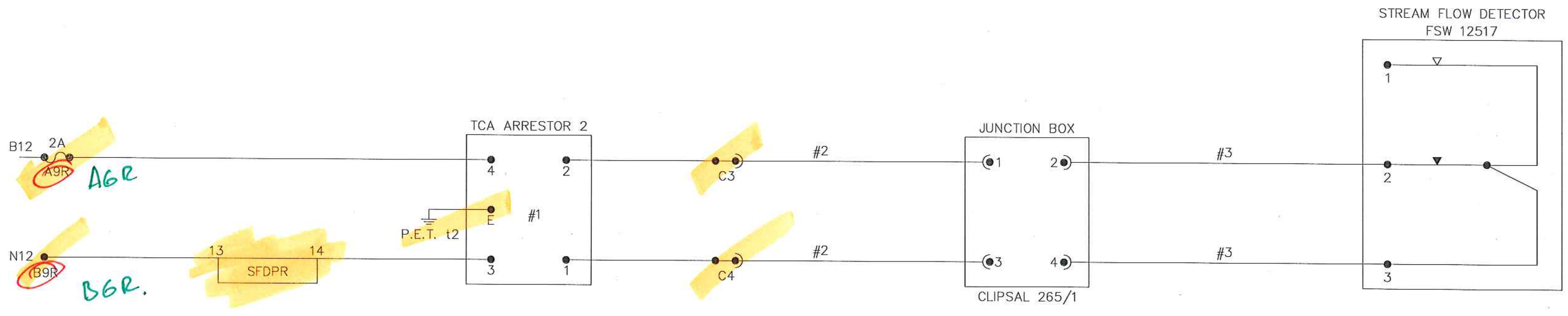
Rev.	Date	Description	Design	App'd	Scale: N/A
0	10/10/12	INITIAL DESIGN			Designed:
					Checked:
					Approved:
					Date:

O'DONNELLGRIFFIN

DARWIN
CULLEN RIVER SFD SITE
2510.995Km
FUSE & TERMINAL ANALYSIS

0

Sheet No.
01–3050–0277



NOTES:
#1 TCA ARRESTOR TC–18CS/S4
#2 DENOTES 7/0.85mm CABLE
#3 DENOTES 0.75mm CABLE
ALL WIRING 24/0.20mm UNLESS OTHERWISE SPECIFIED.
ALL EARTH WIRING 7/0.85mm (G/Y) UNLESS OTHERWIES SPECIFIED.

Rev.	Date	Description	Design	App'd
0	10/10/12	INITIAL DESIGN		

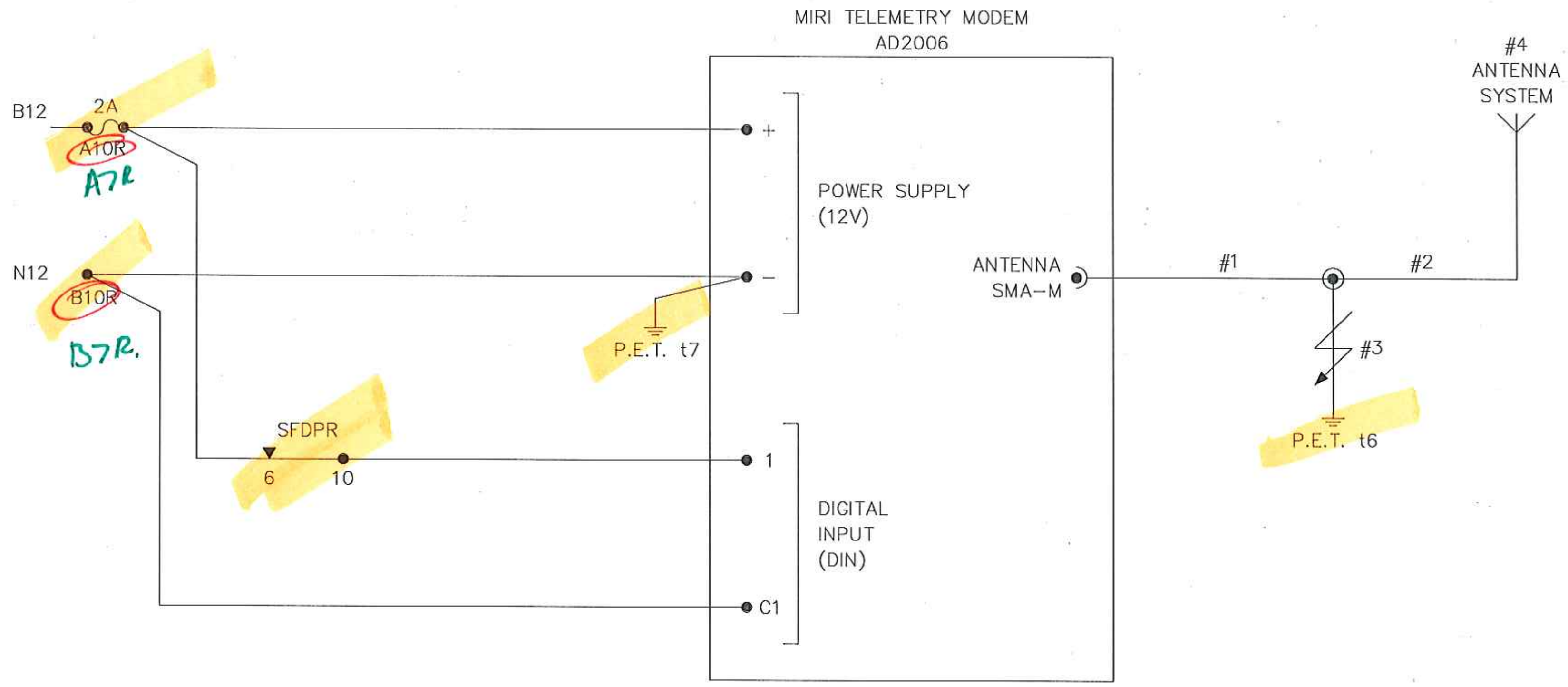
Scale: N/A
Designed:
Checked:
Approved:
Date:

O'DONNELLGRIFFIN

DARWIN
CULLEN RIVER SFD SITE
2510.995Km
SFD CIRCUITS

0

Sheet No.
01–3050–0278



MIRI JUMPER SETTINGS FOR INTERNAL RADIO

JUMPER	J18	J34	J33	J19
OPEN	✓			
CLOSED		✓	✓	✓

JUMPER	J8	J49	J1	J2	J6	J17	J7	J3	J50	J9	J10	J11
A POSITION	✓									✓	✓	✓
B POSITION		✓	✓	✓	✓	✓	✓	✓	✓			

NOTES:
#1 ANTENNA COAXIAL CABLE (TYPE TBD)
#2 ANTENNA COAXIAL CABLE (TYPE TBD)
#3 LIGHTNING PROTECTOR, MIRI PART No. LA–NFF
#4 ANTENNA MOUNTED ON ROOF OF HUT
ALL WIRING 24/0.20mm UNLESS OTHERWISE SPECIFIED
ALL EARTH WIRING 7/0.85mm (G/Y) UNLESS OTHERWIES SPECIFIED

ALL COMMUNICATIONS CONFIGURATION AND EQUIPMENT TO BE CONFIRMED BY COMMS TEAM

Rev.	Date	Description	Design	App'd
0	10/10/12	INITIAL DESIGN		

Scale: N/A
Designed:
Checked:
Approved:
Date:

O'DONNELLGRIFFIN

DARWIN
CULLEN RIVER SFD SITE
2510.995Km
MIRI RADIO MODEM CONNECTIONS

0

Sheet No.
01–3050–0279

XW-MPPT60-150 SOLAR REGULATOR

CONTROL SETTINGS

BATTERY MENU	
Equalize	Stop
Equalization Reminder	Od
Battery Bank	1
Battery Voltage	12V
Battery type	GEL
Capacity Limit	990Ah 48.0A
Recharge Volts	12.5V
Max Absorption Time	180min
Force State	Bulk
Battery Temp	30C
Charge cycle	3 Stage

INPUT MENU	
Tracking	Auto
Max Array Volts	150V
PV Input	Solar Array 1
AUX MENU	
Aux Control Mode	Automatic
Trigger Source	Low Batt Voltage
Trigger Clear	10.5 12.0
Trigger Delay Clear Delay	00:15 00:15
Output Level	12V
Output Mode	Active Lo

NOTE:
SEE XANTREX MANUAL (XW-MPPT60-150) FOR COMPLETE PROGRAMMING INSTRUCTIONS.

Rev.	Date	Description	Design	App'd
0	10/10/12	INITIAL DESIGN		

Scale: N/A
Designed:
Checked:
Approved:
Date:

O'DONNELLGRIFFIN

DARWIN

CULLEN RIVER SFD SITE

2510.995Km
XANTREX SOLAR CONTROLLER SETUP SHEET

0

Sheet No.
01-3050-0280

19.8 Appendix H – Testing and Commissioning Documents

13-05-01 TC-1 Master Test Certificate

Contract No.	NRG-GWA-LX		**Test Certificate No.**		**TC1**
Location	EDITH RIVER		**Master Test Certificate No.**		**GWA/MTC05/001A**
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works				
Customer	Genesee & Wyoming				
Produced By Name	John Cole	**Signature**		**Date**	18-12-12
Checked By Name	John Rogers	**Signature**		**Date**	18-12-12.

Section of Work	TC Number	No. Of Sheets	Signature	Date
Design Closure List Check				
Layout Conforms to Plan				
Locations	**TC-2**	3		10/1/2013
Line Side Signals / Signs	**TC-3**	2		10/1/2013
Track Circuits	**TC-4**	N/A		
Points	**TC-5**	N/A		
Cable Master	**TC-6**	2		10/1/2013
Level Crossing	**TC-7**	N/A		
Factory Acceptance Testing	**TC-8**	2		10/1/2013
Solar Array Test	**TC-10**	2		10/1/2013
Location Earthing	**TC-11**	2		
Principals Test				
Control Table Tests				

Comments:

EARTHING TEST LOGGED

I hereby certify that all products and systems relative to the signalling defined in the closure list above has been tested against, and shown to meet the requirements of the project concept design, engineering details and product specifications.

Time entered into service:	1500	Hrs

	Name	Signature	Date
ODG Tester In Charge	J COLE		10/1/2013
Client Representative	M McCaul.		10/1/2013

ODONNELLGRIFFIN RAIL

13-05-02 TC-2 Site Location Test Certificate

Contract No.	NRG-GWA-LX	Test Certificate No.	TC-2
Location	EDITH RIVER	Master Test Certificate No.	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming		

Technical Verification	Procedure 13-03-02 Section	ODG Tester	Date
Power Supplies	5.10.1		10·1·13
Mechanical Checks	5.1.1		10·1·13
Equipment Secure & Not Damaged	5.1.1		10·1·13
Layout & Profile Checks	5.1.1		10·1·13
Serial Numbers Recorded	5.1.1		10·1·13
Check Labelling Present & Correct	5.1.1	#	10·1·13
Cables Secure & Correctly Run	5.1.1		10·1·13
Cable Tests	4.8		10·1·13
Wire Count to Diagram / Continuity Test	4.2		10·1·13
Wire Count to Analysis	4.3		10·1·13
Setting to Work	**Procedure 13-03-02 Section**	**ODG Tester**	**Date**
Power Supplies	5.10.2		10·1·13
Location Set to Work	5.1.2		10·1·13
Busbar & Earth Leakage Tests	4.7		10·1·13
Circuit Function or S & F Tests	4.4 – 4.5		10·1·13
Changeover / Alterations Tested	6	NA	10·1·13
Final Correspondence Tests	7.2		10·1·13
DED's Tested		NA	10·1·13
Maintenance Records on Site			10·1·13

Record details of tests on testing copy diagrams. Date and sign each section above when complete.

Busbar Readings

12V: 13·8v	+ve Earth: 0v	-ve Earth 0v	**24v:** N/A	+ve Earth: N/A	-ve Earth N/A
12V(I): N/A	+ve Earth: N/A	-ve Earth N/A	**110v:** N/A	+ve Earth: N/A	-ve Earth N/A

Comments:

	Name	Signature	Date
ODG Tester (1)	Chris Dorman		10·1·13
ODG Tester (2)	J Cole		10-1-13
Client Representative			

O'DONNELL GRIFFIN RAIL

13-05-02 TC-2 Site Location Test Certificate

Contract No.	NRG-GWA-LX	**Test Certificate No.**	**TC-2**
Location	EDITH RIVER North Indicator	**Master Test Certificate No.**	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming		

Technical Verification	**Procedure 13-03-02 Section**	**ODG Tester**	**Date**
Power Supplies	5.10.1	[signature]	10·1·13
Mechanical Checks	5.1.1	[signature]	10·1·13
Equipment Secure & Not Damaged	5.1.1	[signature]	10·1·13
Layout & Profile Checks	5.1.1	[signature]	10·1·13
Serial Numbers Recorded	5.1.1	[signature]	10·1·13
Check Labelling Present & Correct	5.1.1	[signature] #1	10·1·13
Cables Secure & Correctly Run	5.1.1	[signature]	10·1·13
Cable Tests	4.8	[signature]	10·1·13
Wire Count to Diagram / Continuity Test	4.2	[signature]	10·1·13
Wire Count to Analysis	4.3	[signature]	10·1·13
Setting to Work	**Procedure 13-03-02 Section**	**ODG Tester**	**Date**
Power Supplies	5.10.2	[signature]	10·1·13
Location Set to Work	5.1.2	[signature]	10·1·13
Busbar & Earth Leakage Tests	4.7	[signature]	10·1·13
Circuit Function or S & F Tests	4.4 – 4.5	[signature]	10·1·13
Changeover / Alterations Tested	6	N/A	10·1·13
Final Correspondence Tests	7.2	[signature]	10·1·13
DED's Tested		N/A	10·1·13
Maintenance Records on Site		[signature]	10·1·13

Record details of tests on testing copy diagrams. Date and sign each section above when complete.

Busbar Readings

12V: 13.8V	+ve Earth: 0V	-ve Earth 0V	**24v:** N/A	+ve Earth: N/A	-ve Earth N/A
12V(I): N/A	+ve Earth: N/A	-ve Earth N/A	**110v:** N/A	+ve Earth: N/A	-ve Earth N/A

Comments:

#1 test log raised labeling to be completed by installation team.

	Name	Signature	Date
ODG Tester (1)	Charlotte Moss	[signature]	10·1·13
ODG Tester (2)	J Cole	[signature]	10-1-13
Client Representative			

O'DONNELL GRIFFIN RAIL

13-05-03 TC-3 Signals Test Certificate

Contract No.	NRG-GWA-LX	**Test Certificate No.**	TC-3
Location	Edith River North Indicator	**Master Test Certificate No.**	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming		

Signal Number	ER SFD	**Signal Type**	SFD Indicator

Technical Verification	**Procedure 13-03-02 Section**	**ODG Tester**	**Date**
Position & Profile Correct to Drawings	5.2.1		10.1.13
Hood, Lenses & Correct Lamps Fitted	5.2.1		10.1.13
Signal Correctly Aligned	5.2.1		10.1.13
ID Plates Fitted & Correct	5.2.1	#1	10.1.13
Internal Wire Labelling Installed & Correct	5.2.1		10.1.13
Cables Secure & Correctly Installed	4.8		10.1.13
Serial Numbers Recorded	5.2.1		10.1.13
Wire Count to Diagram / Continuity Tests	4.2		10.1.13
Setting to Work	**Procedure 13-03-02 Section**	**ODG Tester**	**Date**
Local Correspondence of Aspects	5.2.2		10.1.13
Set & Record Lamp Voltages	5.2.2		10.1.13
Associated Indicators Display Correct Info.	5.2.2	N/A	10.1.13
Signal Sighting	5.2.2		10.1.13
Final Correspondence Tests	7.2		10.1.13
Record Card Complete & On Site			10.1.13

Record details of tests on testing copy diagrams. Date and sign each section above when complete.

Lamp Voltages

Green:	13.63V	Yellow:	13.6V	Red:	N/A	Sub:	N/A
Route Indicator		Primary Side:	N/A	Secondary Side:		N/A	

N/A If Not Applicable

Comments:

NAME PLATE MISSING - TEST LOG 10-1-13 J CORE

SERIAL N° 231533

E = GREEN N° 1166630013

YELLOW N° 1235580015

	Name	**Signature**	**Date**
ODG Tester (1)	CHARLOTTE MOSS		10/01/13
ODG Tester (2)	C. DORMAN		10.1.13
Client Representative			

O'DONNELL GRIFFIN RAIL

13-05-03 TC-3 Signals Test Certificate

Contract No.	NRG-GWA-LX	**Test Certificate No.**	**TC-3**
Location	Edith River South Indicator	**Master Test Certificate No.**	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming		

Signal Number	ER SFD	**Signal Type**	SFD Indicator

Technical Verification	**Procedure 13-03-02 Section**	**ODG Tester**	**Date**
Position & Profile Correct to Drawings	5.2.1		
Hood, Lenses & Correct Lamps Fitted	5.2.1		
Signal Correctly Aligned	5.2.1		
ID Plates Fitted & Correct	5.2.1		
Internal Wire Labelling Installed & Correct	5.2.1		
Cables Secure & Correctly Installed	4.8		
Serial Numbers Recorded	5.2.1		
Wire Count to Diagram / Continuity Tests	4.2		
Setting to Work	**Procedure 13-03-02 Section**	**ODG Tester**	**Date**
Local Correspondence of Aspects	5.2.2		
Set & Record Lamp Voltages	5.2.2		
Associated Indicators Display Correct Info.	5.2.2		
Signal Sighting	5.2.2		
Final Correspondence Tests	7.2		
Record Card Complete & On Site			

Record details of tests on testing copy diagrams. Date and sign each section above when complete.

Lamp Voltages

Green:	13·6V	Yellow:	13·55V	Red:	N/A	Sub:	N/A
Route Indicator		Primary Side:		N/A	Secondary Side:		N/A

N/A If Not Applicable

Comments:

NAME PLATE NOT FITTED - TEST LOG RAISED
HEAD SER N° 231537
E = YELLOW N° 1235580011
GREEN N° 11666330014

	Name	**Signature**	**Date**
ODG Tester (1)	Charlotte Moss	[signature]	10/01/13
ODG Tester (2)	JOHN COLE	[signature]	10/1/13
Client Representative			

Contract No.	NRG-GWA-LX	**Test Certificate No.**		TC6	
Location	EDITH RIVER North Indicator	**Master Test Certificate No.**		GWA/MTC05/001A	
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works				
Customer	Genesee & Wyoming				
Produced By Name	John Cole	**Signature**	[signature]	**Date**	18/12/12
Checked By Name	John Rogers	**Signature**	[signature]	**Date**	18-12-12

Sheet No.	Cable Name	From	To	ODG Tester	Date
1	D	Equipment Case	Drivers Indicator	[signature]	10/1/13

Comments:

	Name	Signature	Date
ODG Tester (1)	J COLE	[signature]	10/1/13
ODG Tester (2)			
Client Representative			

O'DONNELL GRIFFIN RAIL

13-05-10 TC-6A Cable Insulation Test Certificate

Contract No.	NRG-GWA-LX	Test Certificate No.	TC-6A
Location	EDITH RIVER North Indicator	Master Test Certificate No.	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector	Test Voltage:	500V
Customer	Genesee & Wyoming		

Cable Type:	7/0.85mm			Cable Type:				Cable Type:			
No. of Cores:	4			No. of Cores:				No. of Cores:			
From:	Equipment Case			From:				From:			
To:	Drivers Indicator			To:				To:			
Cable Name:	D			Cable Name:				Cable Name:			
Core No	Cont Loop Ω	C-C MΩ	C-E MΩ	Core No	Cont Loop Ω	C-C MΩ	C-E MΩ	Core No	Cont Loop Ω	C-C MΩ	C-E MΩ
1	0.2	>200	>200	1				1			
2				2				2			
3				3				3			
4				4				4			
5				5				5			
6				6				6			
7				7				7			
8				8				8			
9				9				9			
10				10				10			
11				11				11			
12				12				12			
13				13				13			
14				14				14			
15				15				15			
16				16				16			
17				17				17			
18				18				18			
19				19				19			
20				20				20			
Weather Conditions:	DRY			Weather Conditions:				Weather Conditions:			
Reference Core:	2			Reference Core:				Reference Core:			
Wire Count Correct:	YES			Wire Count Correct:				Wire Count Correct:			
Polarity Correct:	N/A			Polarity Correct:				Polarity Correct:			

Comments:

	Name	Signature	Date
ODG Tester (1)	J COLE		10/1/2013
ODG Tester (2)			
Client Representative			

O'DONNELL GRIFFIN RAIL

13-05-09 TC-6 Master Cable Certificate

Contract No.	NRG-GWA-LX		**Test Certificate No.**		TC6
Location	EDITH RIVER South Indicator		**Master Test Certificate No.**		GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works				
Customer	Genesee & Wyoming				
Produced By Name	John Cole	**Signature**		**Date**	18-12-12
Checked By Name	John Rogers	**Signature**		**Date**	18-12-12

Sheet No.	Cable Name	From	To	ODG Tester	Date
1	D	Equipment Case	Drivers Indicator	J COLE	10/1/13

Comments:

	Name	Signature	Date
ODG Tester (1)	J COLE		10/1/13
ODG Tester (2)			
Client Representative			

O'DONNELL GRIFFIN RAIL

13-05-10 TC-6A Cable Insulation Test Certificate

Contract No.	NRG-GWA-LX	Test Certificate No.	TC-6A
Location	EDITH RIVER South Indicator	Master Test Certificate No.	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector	Test Voltage:	500V
Customer	Genesee & Wyoming		

Cable Type:	7/0.85mm			Cable Type:				Cable Type:			
No. of Cores:	4			No. of Cores:				No. of Cores:			
From:	Equipment Case			From:				From:			
To:	Drivers Indicator			To:				To:			
Cable Name:	D			Cable Name:				Cable Name:			
Core No	Cont Loop Ω	C-C MΩ	C-E MΩ	Core No	Cont Loop Ω	C-C MΩ	C-E MΩ	Core No	Cont Loop Ω	C-C MΩ	C-E MΩ
1	0.1	>200	>200	1				1			
2				2				2			
3				3				3			
4				4				4			
5				5				5			
6				6				6			
7				7				7			
8				8				8			
9				9				9			
10				10				10			
11				11				11			
12				12				12			
13				13				13			
14				14				14			
15				15				15			
16				16				16			
17				17				17			
18				18				18			
19				19				19			
20				20				20			
Weather Conditions:	DRY			Weather Conditions:				Weather Conditions:			
Reference Core:	2			Reference Core:				Reference Core:			
Wire Count Correct:	YES			Wire Count Correct:				Wire Count Correct:			
Polarity Correct:	N/A			Polarity Correct:				Polarity Correct:			

Comments:

	Name	Signature	Date
ODG Tester (1)	CHARLOTTE MOSS		10/01/13
ODG Tester (2)	J COLE		10/1/13
Client Representative			

ODONNELLGRIFFIN RAIL	13-05-02 TC-2 Site Location Test Certificate

Contract No.	NRG-GWA-LX	**Test Certificate No.**	**TC-2**
Location	EDITH RIVER South Indicator	**Master Test Certificate No.**	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming		

Technical Verification	**Procedure 13-03-02 Section**	**ODG Tester**	**Date**
Power Supplies	5.10.1	[signature]	10.1.13
Mechanical Checks	5.1.1	[signature]	10.1.13
Equipment Secure & Not Damaged	5.1.1	[signature]	10.1.13
Layout & Profile Checks	5.1.1	[signature]	10.1.13
Serial Numbers Recorded	5.1.1	[signature]	10.1.13
Check Labelling Present & Correct	5.1.1	[signature] #1	10.1.13
Cables Secure & Correctly Run	5.1.1	[signature]	10.1.13
Cable Tests	4.8	[signature]	10.1.13
Wire Count to Diagram / Continuity Test	4.2	[signature]	10.1.13
Wire Count to Analysis	4.3	[signature]	10.1.13
Setting to Work	**Procedure 13-03-02 Section**	**ODG Tester**	**Date**
Power Supplies	5.10.2	[signature]	10.1.13
Location Set to Work	5.1.2	[signature]	10.1.13
Busbar & Earth Leakage Tests	4.7	[signature]	10.1.13
Circuit Function or S & F Tests	4.4 – 4.5	[signature]	10.1.13
Changeover / Alterations Tested	6	N/A	10.1.13
Final Correspondence Tests	7.2	[signature]	10.1.13
DED's Tested		N/A	10.1.13
Maintenance Records on Site		[signature]	10.1.13

Record details of tests on testing copy diagrams. Date and sign each section above when complete.

Busbar Readings

12V: 13.4V	+ve Earth: 0V	-ve Earth 0V	**24v:** N/A	+ve Earth: N/A	-ve Earth N/A
12V(I): N/A	+ve Earth: N/A	-ve Earth N/A	**110v:** N/A	+ve Earth: N/A	-ve Earth N/A

Comments:

#1 Test log raised labeling to be completed by Installation team

	Name	Signature	Date
ODG Tester (1)	Charlotte Moss	[signature]	10.1.13
ODG Tester (2)	J COLE	[signature]	10-1-13
Client Representative			

O'DONNELL GRIFFIN RAIL

13-05-21 TC-10 Solar Array Test Certificate

Contract No.	NRG-GWA-LX	**Test Certificate No.**	**TC-10**
Location	EDITH RIVER	**Master Test Certificate No.**	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming		

Position	Serial Number	Watts	Open Circuit Voltage Test	Short Circuit Current Test
~~A1~~-1	N/A	200	38.78	5.999
~~A1~~-2	N/A	200	39.45	6.045
~~A~~-3	N/A	200	39.75	6.009
A2-1				
A2-2				
A2-3				
A3-1				
A3-2				
A3-3				
A3-4				
B1-1				
B1-2				
B1-3				
B1-4				
B2-1				
B2-2				
B2-3				
B2-4				
B3-1				
B3-2				
B3-3				
B3-4				

Absolyte IIP Settings

Max Boost	V	Return to Boost	V
Boost Taper	V	Temp Compensation	mV
Float Max	V	Low Battery Alarm	V
Flat Min	V	Generator Start	V
Temperature Compensation: Minus 5mV Per Degree Celsius Over 25C		**Cell Terminal Torque Setting:** 11.3 Nm	

	Name	Signature	Date
ODG Tester (1)	CHARLOTTE MOSS		10/01/13
ODG Tester (2)	J COLE		10/1/13
Client Representative			

O'DONNELL GRIFFIN RAIL	13-05-21 TC-10 Solar Array Test Certificate

Contract No.	NRG-GWA-LX	**Test Certificate No.**	**TC-10**
Location	EDITH RIVER South Indicator	**Master Test Certificate No.**	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming		

Position	Serial Number	Watts	Open Circuit Voltage Test	Short Circuit Current Test
A~~1~~-1	N/A	200	38·78	5·99
A~~1~~-2	N/A	200	39·95	6·045
~~A~~-3	N/A	200	39·75	6·009
A2-1				
A2-2				
A2-3				
A3-1				
A3-2				
A3-3				
A3-4				
B1-1				
B1-2				
B1-3				
B1-4				
B2-1				
B2-2				
B2-3				
B2-4				
B3-1				
B3-2				
B3-3				
B3-4				

Absolyte IIP Settings

Max Boost	V	Return to Boost	V
Boost Taper	V	Temp Compensation	mV
Float Max	V	Low Battery Alarm	V
Flat Min	V	Generator Start	V

Temperature Compensation: Minus 5mV Per Degree Celsius Over 25C	**Cell Terminal Torque Setting:** 11.3 Nm

	Name	Signature	Date
ODG Tester (1)	CHARLOTTE MOSS	[signature]	10/01/13
ODG Tester (2)	J COLE	[signature]	10/1/13
Client Representative			

O'DONNELL GRIFFIN RAIL

13-05-21 TC-10 Solar Array Test Certificate

Contract No.	NRG-GWA-LX	**Test Certificate No.**	**TC-10**
Location	EDITH RIVER North Indicator	**Master Test Certificate No.**	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation – Commissioning Works		
Customer	Genesee & Wyoming		

Position	Serial Number	Watts	Open Circuit Voltage Test	Short Circuit Current Test
A1-1	N/A	200	38.66 V	6.95A
A1-2	N/A	200	37.01 V	7.02A
A-3	N/A	200	36.00 V	7.10A
A2-1				
A2-2				
A2-3				
A3-1				
A3-2				
A3-3				
A3-4				
B1-1				
B1-2				
B1-3				
B1-4				
B2-1				
B2-2				
B2-3				
B2-4				
B3-1				
B3-2				
B3-3				
B3-4				

Absolyte IIP Settings

Max Boost	V	Return to Boost	V
Boost Taper	V	Temp Compensation	mV
Float Max	V	Low Battery Alarm	V
Flat Min	V	Generator Start	V
Temperature Compensation: Minus 5mV Per Degree Celsius Over 25C		**Cell Terminal Torque Setting:** 11.3 Nm	

	Name	Signature	Date
ODG Tester (1)	J COLE	[signature]	10/1/2013
ODG Tester (2)			
Client Representative			

TC-11 LOCATION EARTH CERTIFICATE

Contract No.	NRG-GWA-LX	Test Certificate No.	**TC-11**
Location	Edith River North Indicator	Master Test Certificate No.	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation-Commissioning works		
Customer	Genesee & Wyoming		
Purpose of Earth			
Electrode Length	1440mm	Method of Installing Electrodes	NA
Electrode Type	Copper coated rod	Hole Diameter	NA
Cable Size	16mm	Backfill Material	NA
Cable Type	Stranded copper	Other	

Sketch Layout of Electrodes and Earth Grid (Include Distance Between Electrodes)

NOT COMPLETE – TEST LOGGED 10-1-13 J COLE

Test Results

Overall Earth Grid resistance at SER Primary Earth Terminal	Ω

Individual Earth Points

No. 1	Ω	No. 2	Ω	No. 3	Ω	No. 4	Ω
No. 5	Ω	No. 6	Ω	No. 7	Ω	No. 8	Ω
No. 9	Ω	No. 10	Ω	No. 11	Ω	No. 12	Ω
Soil Condition				Soil Type			

- Measure the Overall Earth Grid Resistance at the PET with all Earth Electrodes and earth conductors connected.
- Test earth resistance at each earth electrode point utilising the adjoining equipment earth terminal or the applicable earth tail.

Test Equipment Serial No(s):

	NAME	SIGNATURE	DATE
Certified by O'Donnell Griffin			
Accepted by the Client			

O'DONNELL GRIFFIN RAIL

TC-11 LOCATION EARTH CERTIFICATE

Contract No.	NRG-GWA-LX	Test Certificate No.	**TC-11**
Location	Edith River South Indicator	Master Test Certificate No.	GWA/MTC05/001A
Project / Stage	Northern Territory Stream Flow Detector Installation-Commissioning works		
Customer	Genesee & Wyoming		
Purpose of Earth			
Electrode Length	1440mm	Method of Installing Electrodes	NA
Electrode Type	Copper coated rod	Hole Diameter	NA
Cable Size	16mm	Backfill Material	NA
Cable Type	Stranded copper	Other	

Sketch Layout of Electrodes and Earth Grid (Include Distance Between Electrodes)

NOT COMPLETE TEST LOGGED 10-1-13 J COLE

Test Results							
Overall Earth Grid resistance at SER Primary Earth Terminal					Ω		
Individual Earth Points							
No. 1	Ω	No. 2	Ω	No. 3	Ω	No. 4	Ω
No. 5	Ω	No. 6	Ω	No. 7	Ω	No. 8	Ω
No. 9	Ω	No. 10	Ω	No. 11	Ω	No. 12	Ω
Soil Condition				Soil Type			

- Measure the Overall Earth Grid Resistance at the PET with all Earth Electrodes and earth conductors connected.
- Test earth resistance at each earth electrode point utilising the adjoining equipment earth terminal or the applicable earth tail.

Test Equipment Serial No(s):

	NAME	SIGNATURE	DATE
Certified by O'Donnell Griffin			
Accepted by the Client			